Forage Legumes Containing Tannin – Opportunities & Challenges to Adoption

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Whether grazed or conserved as hay or silage, forage legumes are managed to produce high yields of digestible dry matter (DM) and protein for ruminant livestock. Unfortunately, ~80% of protein in grazed or conserved forages, such as alfalfa, undergoes enzymatic breakdown (proteolysis) during conservation and ruminal digestion to form non-protein nitrogen (N) products. While a portion is converted to nutritionally valuable microbial protein in the rumen, up to 1/3 of the non-protein N in high alfalfa diets ends up being excreted in urine, mainly as urea. Urea is readily converted to ammonia and lost to the atmosphere in the feedlot, and during manure handling, storage, and cropland application. Dietary protein is best used by the animal when digested in the lower gastrointestinal tract after having passed through the rumen. Unfortunately, only ~20% of the original alfalfa protein is actually digested in the gastrointestinal tract to supply amino acids for growth and meat and milk production. Thus, identifying ways to increase the digestion of forage protein would substantially improve protein-use efficiency of livestock, enhance farm profitability, and lessen ammonia emissions to the environment.

Promise & Problems with Tannins

The good news! Unlike alfalfa, some forage legumes like birdsfoot trefoil contain condensed tannins (CTs), which are natural substances binding to and protecting protein from proteolysis during forage conservation and ruminal digestion. Modest amounts of CTs (1-3% DM) in forage can increase the amount of protein passing through the rumen to be digested in the gastrointestinal tract. This can boost milk production and weight gain of livestock. It was illustrated in a U.S. Dairy Forage Research Center (USDFRC) study published in 2013. Substituting alfalfa with birdsfoot trefoil containing up to 1.6% CT in total mixed rations increased milk production from 68 to 78 lbs/day and protein-use efficiency of milk production from 22 to 27%, without affecting feed intake or milk composition. Other studies found urea excretion in urine and ammonia loss from manure were reduced by ~25%. Studies in New Zealand, the U.S., and other countries have also noted improvements in milk production or growth of livestock grazing birdsfoot trefoil. Furthermore, CT-containing forages prevent bloat in cattle and can reduce levels of digestive parasites and methane emissions from ruminant livestock.

The bad news. By contrast, a 2017 USDFRC study found substituting alfalfa with birdsfoot trefoil had little or no effect on milk production, even though CT levels were comparable to the 2013 study. Silage analyses suggested the inconsistent responses among trials were related to the strength of CT binding to protein. Other work has shown the concentration and structural features of CT and their effects on protein digestion vary considerably among forage legume species and varieties, and it is influenced by growing conditions and conservation practices. Excessive concentrations of CT are also known to adversely affect livestock production by depressing the intake of feed and the digestion of protein and other nutrients. Furthermore, the suitability of common forage quality assays and ration formulation methods for CT-containing diets must be validated. Finally, CT-containing forages such as birdsfoot trefoil are lower yielding and less persistent under intensive management than alfalfa and other commonly grown forages.

Efforts to Overcome These Challenges

- **Develop robust analytical methods.** Scientists at the USDFRC and other institutions are working to improve the accuracy of assays for measuring the concentration and composition of CTs in forages. Other work is aimed at evaluating and improving laboratory assays for predicting the ruminal and gastrointestinal degradability of protein in CT-containing forages. Widespread use of these assays will help to ensure diets are optimally formulated to make best use of forages containing CT.
- **Identify optimal CT characteristics for forages.** Improved techniques to isolate, purify, and characterize CTs from a wide variety of plant materials have been developed by scientists at the USDFRC and the University of Reading in the UK. Using these CTs in laboratory tests to evaluate protein precipitation and protein degradation during ensiling and both ruminal and gastrointestinal digestion will help to identify the optimal concentration and chemical characteristics of CT for improving protein utilization by livestock.
- **Develop improved varieties and management practices for CT-containing forage crops.** Scientists at USDFRC have recently developed several new birdsfoot trefoil varieties expected to have appropriate CT concentrations for livestock and improved yield and persistence, particularly for the North Central and Northeastern U.S. regions. Commercial forage breeders and other research groups are also working to develop high yielding alfalfa varieties containing CT for livestock. Agronomic, forage conservation, and feeding studies are the next steps to assess the value of these new varieties and to help develop best management practices for utilizing them on farms.

Through these efforts we anticipate forage farmers in the future will have productive CT-containing forage varieties and an outline of solid forage management practices for improving the profitability and environmental sustainability of dairy and livestock farms.