Improving Silage Preservation & Nitrogen Use Efficiency of Dairy Cattle

U.S. Dairy Forage Research Center Scientists, USDA-ARS

With the goal of improving forage preservation, approximately 250 scientists from around the world will meet at the International Silage Conference in Finland on July 2-4. This will include three researchers from the U.S. Dairy Forage Research Center (USDA Agricultural Research Service) in Madison, WI. Here is a synopsis of the research they will be presenting at the conference.

Co-ensiling Temperate Grasses to Improve Protein Use Efficiency in Ruminants

Preserving high quality forage remains a challenge due to potentially high levels of protein degradation during ensiling. This degraded protein cannot be utilized efficiently by the cow and, therefore, reduces profits for the farmer (more protein supplements must be purchased) and impacts the environment (excess nitrogen is excreted by cattle).

Previous research at the U.S. Dairy Forage Research Center (USDFRC) has shown that there is less protein degradation in some forages, such as red clover, because it contains high levels of both polyphenol oxidase (PPO) and its *o*-diphenol substrates. In comparison, some temperate grasses contain high levels of PPO, but insufficient levels of *o*-diphenol substrates to inhibit protein degradation during ensiling; other grasses contain high levels of *o*-diphenols, but little to no PPO.

Experiments were carried out to evaluate the feasibility of co-ensiling a grass with high levels of PPO (orchardgrass and smooth bromegrass) along with a grass that contains high levels of *o*-diphenol substrates (tall fescue and timothy). All forages were chopped and macerated before ensiling; for the eight different treatments (Table 1) they were either field mixed (planted together as a mix) or mechanically mixed before being ensiled in plastic-wrapped bales.

Table 1. Forage combinations, mixes, yields, and ratios

o-Diphenol Grass	PPO Grass	Mixing Conditions	Yield *(tons/acre)*	Ratio of Forages
None	Orchardgrass	None	1.69	0:100
None	Bromegrass	None	2.47	0:100
Tall Fescue	None	None	1.69	100:0
Timothy	None	None	1.30	100:0
Tall Fescue	Orchardgrass	Field Mix	1.28	46:54
Tall Fescue	Bromegrass	Field Mix	1.89	30:70
Timothy	Orchardgrass	Field Mix	1.80	30:70
Timothy	Bromegrass	Field Mix	1.64	34:66
Tall Fescue	Orchardgrass	Mechanical		50:50
Tall Fescue	Bromegrass	Mechanical		50:50
Timothy	Orchardgrass	Mechanical		50:50
Timothy	Bromegrass	Mechanical		50:50

After a minimum of 30 days, silage bales were opened and fed to young lambs either ad libitum or at restricted levels. Lambs were used because their feed intake to body weight ratio is similar to that of dairy cattle, but they require much less feed; this is useful when conducting trials with limited amounts of experimental feedstuffs. Total feed intakes were measured as well as total feces and urine excretion by individual lambs. Nitrogen use efficiency was calculated for each feeding treatment. For most of the silages, nitrogen use efficiency increased in lambs fed the co-ensiled forages compared to the single forage controls. The positive effect was greater when the tall fescue was used as the *o*-diphenol substrate compared to timothy.

By showing an animal response, this research reemphasizes the practical aspect of protein protection by PPO when a suitable substrate is present during ensiling, and it shows the feasibility of co-ensiling grasses to provide both the PPO and substrate (*o*-diphenol) to make this happen. More research is needed to determine the most practical ways to do this at the farm level.

— Jane Marita, Ron Hatfield, Geoffrey Brink

Effects of Replacing Alfalfa Silage with Birdsfoot Trefoil Silage Containing Different Levels of Condensed Tannins

Extensive degradation of crude protein in ensiled alfalfa impairs nitrogen utilization when these silages are fed to lactating dairy cattle; the presence of tannin has been shown to reduce this protein degradation and birdsfoot trefoil is a legume with naturally occurring tannin. Therefore, one area of research at the USDFRC has focused on ways to introduce tannin into silage.

A previous study showed feeding birdsfoot trefoil with elevated levels of condensed tannins reduced silage non-protein nitrogen (a sign of less protein degradation) and was associated with improved yield of milk and milk components. This follow-up study compared milk production on silages prepared from subsequent harvests of the same birdsfoot trefoil germplasm to that of alfalfa silage. Forages from birdsfoot trefoil were selected for low, medium, and high concentrations of naturally occurring tannin.

Thirty-two multiparous Holstein cows were fed total mixed rations in which 50% of the dry matter was from alfalfa silage or one of the three birdsfoot trefoil silages. There were no differences in yield of milk or energy corrected milk (milk volume equalized for energy content based on standard concentrations of fat, protein, and lactose) on the four diets (Table 2). But there was a greater yield of milk protein on the birdsfoot trefoil silages with low and medium levels of condensed tannins; and milk urea nitrogen (MUN) was reduced on all birdsfoot trefoil diets, indicating improved nitrogen use efficiency relative to the diets with alfalfa silage. These two factors indicate nitrogen utilization was improved when birdsfoot trefoil replaced alfalfa silage in the diets of lactating cows.

While birdsfoot trefoil will not be replacing alfalfa in dairy cattle rations any time soon, this research confirms the effect of condensed tannins on nitrogen use efficiency. Research at other institutions is looking at ways to introduce condensed tannins into alfalfa.
— *Glen Broderick, Ursula Hymes-Fecht, Richard Muck, John Grabber*

Lactating Cow Response to Alfalfa Silage Inoculated with *Lactobacillus plantarum*

Inoculants are used in making silages to shift silage fermentation in a direction that better preserves the crop, thereby preserving more dry matter. Inoculated silages have also been shown to improve milk production in lactating dairy cattle, but the mechanisms involved in this effect are not clear. Previous in vitro (test tube) research has suggested that inoculated silage effects on milk production may be tied to greater production of rumen microorganisms.

Table 2: Production of dairy cows fed silage from alfalfa or birdsfoot trefoil with varying levels of condensed tannins.

	Alfalfa	Low Tannin BFT[1]	Medium Tannin BFT[1]	High Tannin BFT[1]
Milk, lbs/day	92.2	93.5	95.5	92.2
ECM[2], lbs/day	89.7	91.1	93.0	87.1
Milk Protein, lbs/day	2.78	2.93	2.93	2.80
MUN[3], mg/dl	14.8	12.8	12.4	12.0

[1]birdsfoot trefoil, [2]energy corrected milk, [3]milk urea nitrogen

To determine if alfalfa silage treated with an effective *Lactobacillus plantarum* inoculant could produce a milk production response in cows that was proportionate to the in vitro response, the USDFRC conducted a lactation trial. Alfalfa was ensiled with and without a *Lactobacillus plantarum* inoculant. The two alfalfa silages were of similar dry matter, crude protein, fiber, and ash concentrations, but the inoculant was effective in reducing silage pH and shifting fermentation toward lactic acid. Composition was similar between the two diets fed to 28 multiparous Holstein cows in early lactation.

Compared to the diet with the untreated alfalfa silage, the diet with inoculated alfalfa silage increased milk production but had no effect on fat-corrected or energy-corrected milk production. There was a trend for increased dry matter intake with the *Lactobacillus plantarum* diet, but efficiency of milk production was not affected by treatment. Milk urea nitrogen was reduced with the *Lactobacillus plantarum* diet, suggesting that more of the degraded protein on the *Lactobacillus plantarum* diet was being converted to microbial protein and less to ammonia in the rumen.

In conclusion, silage inoculated with *Lactobacillus plantarum* increased milk production and reduced milk urea nitrogen, supporting the hypothesis that the inoculated silage is increasing formation of microbial biomass in the rumen.
— *Richard Muck, Glen Broderick, Antonio Faciola and Ursula Hymes-Fecht*

Silage Extracts Used to Study the Mode of Action of Silage Inoculants in Ruminants

Knowing that there is an increased production of rumen microorganisms and an increase in milk production when cows are fed diets with inoculated silage, the next related research project at the USDFRC was designed to see if there is an extractable factor from inoculated silage which enhances rumen microbial activity. One alfalfa haylage and two corn silages were made in mini-silos with two treatments: untreated (control) or inoculated with *Lactobacillus plantarum*.

The silages were analyzed for pH, fermentation products, in vitro true dry matter digestibility, in vitro microbial biomass yield, and standard nutritive characteristics. In addition, 1:1 aqueous and 80% ethanol extracts of control and inoculated silages were prepared to study their effects on in vitro ruminal biomass yield and gas production.

Alfalfa silage treated with *Lactobacillus plantarum* had the highest microbial biomass yield, greater than the alfalfa control. However, treatment had no effect on microbial biomass yield in the two corn silages. For alfalfa, the extracts made from inoculated silage had a reduced microbial biomass yield in the water extract and an increased yield in the ethanol extract when compared to the control silage. For corn silage, the extracts showed no effect on microbial biomass yield for the control versus inoculated silages. The direct application of *Lactobacillus plantarum* to the rumen inoculums had the lowest values of microbial biomass yield and gas production.

These results indicate that substrate availability limited rumen bacterial growth except in the alfalfa silage where the inoculant affected in vitro microbial biomass yield; here, ethanol extracts of inoculated silage exhibited an increase in both microbial biomass yield and gas production, suggesting that the ethanol extract may contain the factor in inoculated silage that improves rumen microbial growth.

While the results in alfalfa are interesting, more research is needed to confirm the effect and to investigate the differences in the two extracts that may be affecting rumen microbial growth.
— *Richard Muck, Zwi Weinberg, Francisco Contreras-Govea*