"FIRE AND WATER"

A REVIEW OF FORAGE PRESERVATION METHODS AND PRODUCTS

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Heat and water. At first, man feared them both. But as he evolved, man learned to use both as tools. Fire for warmth and food. Water for nourishment and transportation.

Management of heat and water have been key factors in the development of our civilization. For energy, technology, transportation, and food production.

And the search for new and better management techniques for heat and water is an ongoing process. A process that continually seeks to maximize their potential.

Management of these two natural elements is key to maximizing the potential for your forage. All the way from irrigation and timely rainfall, to moisture content at harvest, to the fermentation process in the pit or silo.

In hay production for example, being able to bale hay at 20 to 25 percent moisture would have several distinct advantages.

First of all, you would harvest more hay and better quality hay because of reduced leaf loss.

You would substantially reduce the chance of rain damage because your hay would spend less time in the windrow.

There would be less machinery damage to your crop.

And you would be able to re-irrigate earlier.

On the other hand, the major reasons for poor quality hay are numerous as well.

1) Low moisture content when baled.
2) Excessive leaf shatter and stem loss.
3) Rain damage.
4) Spoilage during storage.
5) Low levels of energy and protein.

Alfalfa is roughly 50% leaf and 50% stem, and more than two-thirds of every alfalfa plant's total protein and energy are located in the leaf.

Good quality alfalfa contains 20% crude protein, with 70% of that protein located in the leaf, and 30% found in the stem. And the energy and protein found in the leaf is much more digestible than that found in the stem,

USDA research shows that when alfalfa is baled at 10% moisture, conservatively 50% of the leaves are lost. And with the loss of leaves, there is a corresponding loss of digestive protein as well.

On the other hand, when you bale hay at 20% moisture, your leaf loss is reduced to 20% of the alfalfa plant. Baling your alfalfa at 20 to 25% moisture increases the amount of retained protein and energy by a whopping 60% over hay baled at 10% moisture.

Simply stated, if you are able to harvest and store high-moisture hay, your yield per acre in terms of tonnage and total digestible nutrients increases considerably. It can make a huge difference in your bottom line.

However, one problem must be dealt with when baling "high-moisture" hay and that's mold. Mold can grow anytime the moisture level in your hay reaches 15% or more.

The task for maximizing the potential of your silage and haylage is very similar to producing high-quality baled hay, with one exception. Here, the key is managing heat, the critical natural element in the fermentation process.

But, unfortunately, producing good-quality forage has been pretty much of a "crap-shoot" for you up until now. Because regardless of your efforts to make sure you've had a fine chop at harvest, fast fill, and good pack following by fairly rapid pit and silo removal, your management techniques have been very dependent on nature supplying the right amount of "good bugs" to eliminate the source of oxygen for yeast and mold-producing organisms. Bacteria that leave you with poor-quality silage and haylage with shrinkage of 25% or more, reduced levels of energy, protein and total digestible nutrients, reduced pit and bunk life, all because of excessive amounts of yeast and mold producing organisms.

In terms of dollars, USDA research has found that shrink and loss of nutrients can cost producers substantial amounts of money. This chart shows the dollar loss that results from a particular percent loss of protein per ton of silage. This example uses 44% soybean oil meal (SBOM) as a protein substitute at a price of $225 per ton, or 11.25 cents per pound.

Here we can see the dollars lost per ton due to shrinkage of up to 25%, which is quite common, on silage valued from $11 to $22 per ton. Shrink is defined as the difference between weight-in at filling time and weight-out at feeding.

Fortunately, the science of forage production has come a long way in the last 30 years. Because now it's possible to actually manage the fermentation process with forage inoculants. When you use forage inoculants, you have actually opened the door to controlling fermentation. Managing what used to be destructive heat and moisture.

Forage inoculants allow you to:

1) Control shrinkage.

2) Minimize protein and TDN losses

3) Substantially increase storage and bunk life.

4) Drastically reduce the production of yeast and mold.

Producing silage and haylage using a forage inoculant is no different than using vinegar and a mason jar to make pickles or sauerkraut.

Vinegar is acedic acid and is used in the pickeling process because it rapidly lowers the pH of the fermenting cucumber. And the mason jar is used because it cuts off the supply of oxygen to that fermenting cucumber. The combination of vinegar (acedic acid) and the mason jar (lack of oxygen) stops the fermentation process cold in the cucumber and preserves what is now a pickle.

It would be prohibitively expensive to pour vinegar on your forage Not to mention the corrosive effect it would have on your equipment.

An alternative though, would be to introduce a concentrated dosage of naturally occurring organisms into your forage that have the ability to shed a "vinegar-like" waste product, namely lactic acid and acedic acid - that rapidly lowers the pH of your forage and consume the available oxygen, thereby controlling the fermentation process, in what now has become silage or haylage.

Forage inoculants insure the presence of acid-producing bacteria that reduce heat and mold producing organisms. They suppress the spoilage bacteria spores, active in high-moisture environments, that produce protein-damaging heat and destructive molds. Plus they speed the fermentation process by rapidly dropping the pH level and consuming the available oxygen in your forage, just like vinegar and the mason jar.

The use of inoculants allows you to finally realize the true food value potential of your forage. Proper application of inoculants allows you to bale hay at 20 to 25 percent moisture which means:

Higher yield per acre because of reduced leaf loss

2) Better quality hay because of increased protein, energy, and total digestible nutrient retention.

3) Quicker harvest reduces weather as a factor.

4) Substantially reduced spoilage

And for silage and haylage, the advantages are just as significant

Substantial reduction of shrink.

2) More protein, energy and TDN per ton.

3) Increased storage and bunk life.

4) Limit the production of yeast and mold.

Forage inoculation - the concept is simple. As simple as heat and water management Management of the fermentation process, that allows you to finally realize the food production potential of your valuable forage.

Now that you have a basic idea of how bacterial enzyme-type hay treatment products work let's discuss the other three specific functions of viable, naturally-occurring microbials.

THE THREE MICROBIOTIC PROPERTIES

Competitive Antagonism (1)

Beneficial organisms grow rapidly and compete with disease-causing pathogens for space and nutrients.

Organic Acid Production (1)

Probiotic organisms secrete or shed lactic and acetic acid which can withstand pH range of 3.0 - 9.0.

The ability of lactic acid bacteria to grow at both acidic and basic conditions gives the bacteria a definite advantage over the disease-causing pathogen.

Inhibitory Substance Shed (1)

Several organisms including Strep. faecium and L. acidophilus shed substances that inhibit growth of pathogens such as E. coli, salmonallae, pseudomonas, shigellae and pneumococci, and clostridial sp.

Let's discuss each properly in depth.

COMPETITIVE ANTAGONISM

Beneficial organisms grow rapidly and compete with mold-causing organisms for:(2)

1) Space

2) Nutrients

Streptococcus organisms start the fermentation processes (3) Strep. faecium, Cernelle 68 strain, is typically the first organisms to grow in forage inoculant products.

(1) L.D. Muller and A. Brink. 1986. The effect of Feed-Mate Ruminant on Volatile Fatty Acid concentrations and In Vitro dry matter disappearance.

(2) Daly, C., W.E. Sandine, P.R. Ellider. 1972. J. M'lk Food. 35:349

(3) Starr, M.P., Stolp, M., Truper, H.G., Balows, A., Schlegol, H.G. 1981. The Prokaryotes: A Handbook of Habitats, Isolation, and Identification of BXcteria. Springer-Verlag Berlin Heidelberg.

Strep. faecium, Cernelle 68 strain, organisms reproduce at least two times faster than most other beneficial organisms. This fast-paced Strep. faecium strain doubles every 18-19 minutes.

Midway in the fermentation process L. acidophilus (3) L. plantarum and L. brevis begin to grow. Once a beneficial bacteria attaches to a site, competing organisms cannot obtain nutrients. (4) This limits the growth of mold and yeast.

Heat-tolerant Pediococcus organisms contribute to the growth process in the late stages of fermentation. (3) These organisms insure completion of a successful fermentation process.

ORGANIC ACID PRODUCTION

Lactic and acetic acids are naturally created organic acids. They lower the pH of the forage and can serve as an energy source for the consuming animal. (5) These acids are waste products secreted by the beneficial organism. Lactobacillus plantarum leads the list in its ability to shed a volume of lactic acids (vs) colony forming units. (6) This is one of the principle reasons you will find L. plantarum in most forage inoculants.

Beneficial organisms can withstand a pH range of 3.0-9.0 (3) This gives beneficial bacteria an advantage over most mold and spoilage organisms. In the presence of their own waste product, lactic and acetic acid, beneficial organisms will also die. The ability to survive, particularly in a low pH, allows the beneficial bacteria to inhibit growth of most spoilage organisms.

INHIBITORY SUBSTANCE SHED

Inhibitory substance shed is one of the most unique qualities of beneficial organisms. Several beneficial organisms shed the substances that inhibit growth of specific spoilage-forming organisms.

L. acidophilus, Strep. faecium and L. brevis produce substances (7) that inhibit organisms such as E. coli, salmonellae, pseudomonads, shigellae, pneumococci and others (8). These substances, acidophilus, lactolin and acidolin are naturally produced inhibitors which tend to be bacteriostatic (growth-arresting) to a specific spoilage organism (7).

L. acidophilus also has the ability to inhibit growth of certain bacteria by producing Hydrogen peroxide (H_2O_2), an anti-microbial substance (6) Hydrogen peroxide is a fairly weak boned molecule and can be split to form water (H_2O) and a free atom of oxygen (O-). Consequently, Hydrogen peroxide is an oxygen supplier in certain organisms for microbial growth.

Anaerobic organisms, such as clostridial organisms grow best in oxygen-free environments. Clostricial sp. compete for space and also tolerate low pH levels of the fermenting forage Oxygen, supplied by L. acidophilus - produced Hydrogen peroxide, is not easily tolerated by any anaerobic bacteria.

(4) Couman, G.L. and L.U. Davis. 1977. Use of Lactobacillus acidophilus in Livestock Feeding. 28th Ann. MOntana Nutr. Conf., p. 75.

(5) Cunnotte, G.H.M. 1983. Role of DL - Lactic Acid as an Intermediate in Rumen Metabolism of Dairy Cows, J. An. Sci. 56: 1222.

(6) Bergey's Manual of Determinative Bacteriology. Eighth Edition, 1974. Williams & Wilkins Co, Baltimore.

(7) Sandine, W.E. 1979. Rdles of Lactobacillus in the Intestinal Tract. J. of Food Protect-tion. 42:259.

(8) Shahami, K.M., F.J. Vakil, and A. Kilara. 1978. Celtured Dairy Prod. J. 11:14

There are five basic classifications of hay treatment-type products

Live Inoculums and Enzymes

Live bacteria and enzymes breakdown the cellulose to make more nutrient available for the inoculant bacteria to grow and multiply.

Germain's Forage Inoculant is an example of this classification.

II Enzymes

The byproducts of fermentation are enzymes which breakdown the cellulose and make the nutrient more available to whatever fermentative bacteria may be present.

III.Nutrient Additions

Nutrient additions include ammonia, minerals and molasses. Ammonia is highly alkaline and tends to slow the fermentation process. In addition, it takes six units of energy for an animal to convert each unit of the ammonia to protein.

IV Chemical Preservatives

Most chemical preservatives contain propionic or other organic acids which, if used in correct amounts, reduce the growth of putrefaction bacteria. They do not add bacteria. If sufficient lactic acid-producing bacteria are not present in the forage crop, the process of fermentation is delayed. Frequently an insufficient amount is applied and spoilage follows. Adding too much acid reduces palatability of the forage.

Enzymes and Chemicals

Enzymes aid in providing nutrition to bacteria. The chemicals assist in holding down the growth of the putrefying bacteria.

Generally, there are seven most commonly used microbials in the live inoculum type products. Here is a brief explanation of what each organism contributes and it's optimum growth ranges.

Lactic Acid-Producing Bacteria	Preservation Contribution	pH Range	Temperature Range
Streptococcus faecium Cernelle 68 strain	-Lactic Acid -Naturally inhibitory substance shed -Early fermentation abilities	Both high and low 4.0-7.5	Low 50°-95° F.
Streptococcus cremoris	-Lactic Acid -Early fermentation ability	Low 4.0-7.0	Low 50°-90° F.
Streptococcus diacetylactis	-Lactic Acid -Flavoring -Early fermentation ability	Low 4.0-7.0	Medium 50°-90° F
Lactobacillus plantarum	-Keylactic -Acid shedder	Medium 4.0-6.8	Medium 60°-104° F.
Lactobacillus acidophilus	-Lactic Acid -Inhibitory -Substance Shed	Medium 4.0-6.8	High 60°-110° F.
Lactobacillus brevis	-Lactic Acid -Acetic Acid (bunk life contribution)	Low 4.0-6.8	Medium 75°-104° F.
Pediococcus acidolactici	-Lactic Acid -Flavoring -Late fermentation ability -High temperature tolerance	Low 3.5-6.5	High 80°-115° F.

Enzymes are also commonly combined with live inoculum products and are especially important when used for baled hay treatments.

WHY ARE ENZYMES IMPORTANT?

1) Enzymes convert complex starch and protein into a simple food source for our bacteria.

2) Enzymes deliver the forage in a more readily digestible form to your livestock.

Enzyme	Silage Function	Source
alpha amylase	Initiate plant starch breakdown and speed complete liquification of starch to sugars for fermentation at lower pH.	Bacillus subtilis and Aspergillus oryzae
protease	Breaks down proteins to amino acids and peptides.	B. subtilis
cellulase	Dissolves cellulose and reduces plant gums to nutrient sugar.	B. subtilis

The following is one of the most complete studies on baled hay preservation which was conducted at the Pecos Valley Agricultural Experiment Station, New Mexico State University This is selected portions of Research Report 509, New Mexico State University, Ag. Exp. Station:

ALFALFA HAY PRESERVATIVE TRIAL IN THE PECOS VALLEY

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Bill Melton, Department of Crop and Soil Sciences

Hay preservatives are chemical or biological products designed to reduce or prevent hay losses that result from spoilage. The potential advantages of these products revolve around the possibility of baling at higher than average moisture. Boling higher than normal mositure hay would shorten curing time in the windrow and, thus, reduce possible losses from rain, shorten the time between irrigations by getting hay out of the field quicker; and increase hay yield and quality by reducing leaf loss. Nehir et al., in Pennsylvania, found 22% of the standing alfalfa crop was lost in the mowing, curing and baling operations of harvest (1).

This study was to determine the effects of hay preservatives and baling at higher than normal moisture content on forage yield and quality of alfalfa hay produced in the Pecos Valley of New Mexico.

Bale evaluations were made three to four weeks after baling by sawing 20 bales from each treatment along the long axis between tie wires. The cut face of one bale half was used to locate any spoiled areas. The other half was dissected and visually evaluated for color, presence or absence of fermentation, mold, mildew and dust. The odor was also determined and color of dust noted.

Results and Discussions

Forage yields from the plots baled at a higher than normal moisture concentration with a preservative were about double that obtained when the producer decided the field was ready for baling under normal circumstances (table 1). Based on the average yields from the hand-harvested check plots, 11% of the field's potential yield was lost when baling at a higher than normal moisture concentration with a preservative, compared to a 59% loss in the standard check. This loss was reflected in percentages of leaves and stems and in protein concentration in the hay. Leaf composition in the hand-harvested samples was 60%; percentage leaves in the high moisture hay baled with a preservative was 58, while percentage leaves in the standard check was only 45. Protein concentration in the hand-harvested plots was 21%; protein concentration in the high moisture hay baled with a preservative was 19%, and the standard check contained only 13% protein.

There was no significant differences among preservatives in forage yield, percentage of leaves and stems, protein concentration of the hay or bale moisture, but preservative treatments were significantly different from the standard check for all indices in Table 1. These data show large increases in alfalfa hay yields and quality are possible by baling at higher than normal moisture levels with a preservative.

These data indicate baling alfalfa hay at a higher than normal moisture content with an efficient preservative can reduce harvest losses and increase yield and quality of the product

The following is an economic analysis of the trial conducted by New Mexico State University's Ag. Experiment Station and reported in Research Report 509:

"This study was to determine the effects of hay preservatives and baling at higher than normal moisture content on forage yield and quality of hay produced in the Pecos Valley of New Mexico". From this study we can make the following conclusions about Germain's Forage Inoculant 300X for effectiveness and economics:

1) Performance of proprionic-based preservatives (vs) Forage Inoculant were both equally effective up to a moisture content of 22%.

2) Forage Inoculant 300X treated hay when harvested yielded 1,365 lbs (per acre equivalent) than the standard check hay.

3) 1,365 lbs. per acre advantage at $80 per ton value of alfalfa gives an added value of $54.60/a.

4) Forage Inoculant 300X treated hay yielded a 5% higher protein content than the standard check.

5) 5% higher protein means 304 lb.s per acre additional protein raised.

6) To replace 304 lbs. of protein would require feeding 691 lbs. of 44% soybean meal

7) 691 lbs. of soybean meal at $225/ton yields a hidden value of added protein value of $61.33/ton of alfalfa.

8) A $54.60/acre added value alone would mean that for every $1 spent on Forage Inoculant 300X, the producer would receive $28.74/acre in added value.

$1 spent

$28.74 returned

(Refer to Table 1, Research Report 509. Effects of time of baling and hay preservation application on forage yield, percentage of leaves and stems, protein concentration and moisture concentration of baled alfalfa hay.)

Standard plot size - 14' x 601' or .2 acres.
Forage Inoculant 300X treated hay baled at 48 hours after cutting. Standard check (non-treated hay) baled at 96 hours after cutting.