# Stair Steps to Quality Silage: DuPont Pioneer Inoculant Development

Inoculating silage crops is a critical component in fermentation success. Bacterial inoculants have been around for many years, but only recently have the efforts of microbiologists been employed to improve on the original strains used in the industry. Today, advanced bacterial inoculants from Dupont Pioneer are designed to perform in a variety of fermentation environments. These modern inoculants are capable of delivering a higher level of performance in protecting, preserving and enhancing the quality of silage during all phases of fermentation and feedout.

In the world of bacterial inoculants, there are two key families of bacteria that are used for silage crops, namely *Lactobacillus plantarum* and *Lactobacillus buchneri*. Extreme differences exist between these two families as well as within each family. These differences influence fermentation success and the ability to perform well under different environments.

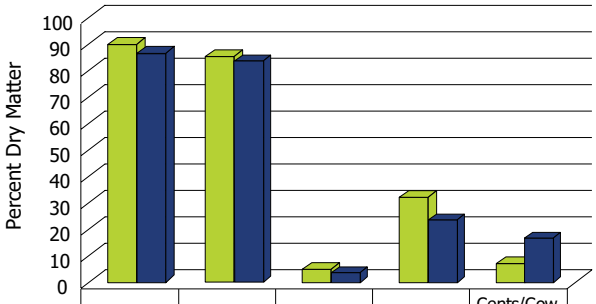
DuPont Pioneer microbiologists have been working since 1978 to understand these differences and have developed the scientific capabilities to screen, quantify and evaluate bacterial strain combinations as well as test performance in the field. This scientific capability has led to a continuous progression of new bacterial inoculants designed to be compatible with the major silage crops in the world.

Today, Pioneer® brand silage inoculants are very efficient at fermentation, resulting in enhanced dry matter recovery of silages during both early fermentation and feedout. These inoculants are designed to be crop specific and to enhance the nutrient value of the ensiled crop. The end result is improved animal performance and feed cost savings.

## Step 1: Control Fermentation

The process of fermentation is both biological and chemical in nature. One of the most fundamental chemical activities that occurs is the production of acids that reduce silage pH. Lowering silage pH together with oxygen elimination prevents spoilage organisms from growing and thus stabilizes the silage. Without the addition of a bacterial inoculant designed to control this process, only naturally occurring epiphytes are available to produce these acids and lower pH. Although the end result may be an ensiled crop, the cost of allowing the natural bacteria to ferment the crop can be extremely high.

The initial fermentation process is accomplished when homo-fermentative bacteria (*L. plantarum*) convert sugars (energy source) to lactic acid. Naturally occurring bacteria are typically very inefficient during this process and consume more energy than is required of the most efficient *L. plantarum* strains. Pioneer® brand inoculants have been developed to contain the most efficient strains of bacteria available. These efficient strains help to reduce the "energy cost" of preservation. These energy savings directly translates to reduced shrink and allows for greater dry matter recovery of three to five percent during the initial phase of fermentation (Figure 1).




| | Treated | Control | Difference | % Difference | Cents/Cow per Day Savings* |
|---|---|---|---|---|---|
| Alfalfa | 90.0 | 85.1 | 4.9 | 32.2 | 7 |
| Corn Silage | 86.7 | 83.4 | 3.3 | 23.2 | 17 |

**Figure 1.** Dry matter recovery of Pioneer brand inoculated and control silage in university studies, 1981-1995.

## Step 2: Right Bacteria, Right Crop (Target Specific Crops with Inoculants)

Bacterial inoculants are designed to work best with specific crops. In studying bacterial strains that improve front end fermentation, Pioneer microbiologists discovered that some strains of bacteria were better for corn, others were better for alfalfa and still others worked better for grasses. Matching strain and crop helps drop the pH level more quickly and allows more efficient preservation of dry matter than before. Using this approach, Pioneer® brand 1132 for corn silage, Pioneer® brand 1189 for high moisture grain and Pioneer® brand 11H50 for alfalfa silage were developed to meet specific crop needs (Figure 2).




**Figure 2.** DuPont Pioneer researchers have developed inoculants tailored to meet the specific fermentation needs of various types of forage. Those products are listed with their crop in this figure.

## Step 3: Manage Aerobic Stability at Feedout

The ability to deliver fresh feed from the silo to livestock is critical. When silage is re-exposed to oxygen at feedout time, the aerobic organisms present in the silage begin to grow again. These organisms are typically yeasts and mold-producing fungi. When they grow, they consume energy, often resulting in heating that is very costly in both the quantity and quality of fed silage. In fact, one of the primary energy sources for growth of yeasts and fungi is lactic acid. As these organisms consume lactic acid, pH rises again and even more damage can occur to

silage, resulting in moldy, lower energy feed.

In the 1990s, Dupont Pioneer researchers identified strains of *Lactobacillus buchneri* that could be put in combination with crop-specific, fermentation-controlling bacteria that dramatically improves aerobic stability (bunk life). These inoculants provide on average 100 more hours of stability (time before heating occurs) than untreated silage (Figure 3).

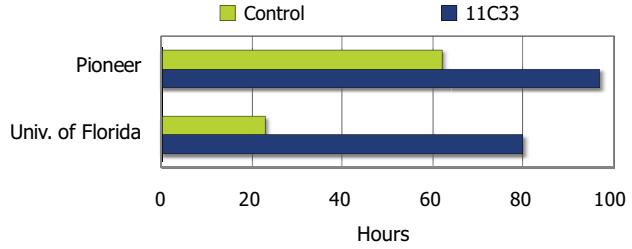



**Figure 3.** Aerobic stability: time required to increase silage temperature by 5°F after exposure to air.

*L. buchneri* is a hetero-fermentative species and will typically produce 50% lactic acid and 50% acetic acid. Acetic acid is a weaker acid than lactic acid, so it will lower the pH at a slower rate and the final pH is typically slightly higher. However, acetic acid is a very good yeast inhibitor and reduces heating and the resulting losses during feedout. By preventing yeast formation, the resulting feed is more consistent and stable while maintaining high forage quality.

Today, Pioneer offers inoculant technology that combines *L. plantarum* strains that produce lactic acid with *L. buchneri* strains that produce acetic acid to preserve quality from initial storage through feedout. These combination inoculants are designed for each crop species being ensiled and include Pioneer® brand 11C33 for corn, Pioneer® brand 11B91 for high-moisture corn and Pioneer® brand 11G22 for grass and alfalfa.

## Step 4: Enhance Fiber Digestibility and Nutrient Availability

The most recent innovation in bacterial inoculants from Pioneer has targeted enhanced fiber digestibility and nutrient availability of the ensiled crop. Researchers discovered a unique strain of *L. buchneri* producing two key enzymes (ferulate and acetyl esterase enzymes) that improve silage quality, especially the digestibility of fiber.

Grass and legume plants contain three primary structural components to help them stand – lignin, cellulose and hemicellulose. Lignin bonds with the cellulose and hemicellulose. However, lignin is indigestible in ruminant animals and will pass through along with some of the cellulose and hemicellulose. As a result, animals cannot take full advantage of the energy in the cellulose and hemicellulose. The enzymes produced by the unique *L. buchneri* strains found in Pioneer® brand Fiber Technology inoculants can separate the lignin from the cellulose and hemicellulose, allowing rumen microbes to use these two fiber sources as energy.

A 2009 to 2010 study by Canadian researchers at the Lethbridge Research Centre (Agriculture and Agri-Food Canada, Lethbridge, Alberta) shows the results of Fiber Technology on animal performance. When beef cows were fed barley silage treated with Pioneer® brand 11GFT inoculant, the treated silage improved aerobic stability and feed efficiency. Steers consuming 11GFT-treated barley gained more weight per pound of ration with an overall feed efficiency improvement of 8.9% (Table 1).

**Table 1.** Results from Lethbridge (AAFC) Barley Silage Feeding Trial (Addah, et al., 2011).

| Fermentation | Control | 11GFT | Advantage |
|---|---|---|---|
| Silage pH | 3.99[a] | 4.43[b] | |
| Lactic acid % | 7.40[b] | 3.85[a] | |
| Acetic acid % | 1.73[a] | 4.24[b] | |
| Lactic: Acetic acid ratio | 4.3 | 0.9 | |
| Aerobic stability (days)[1] | 6 | 21 | +15 days |
| **Animal Performance** | **Control** | **11GFT** | **Advantage** |
| Animal start weight (lbs) | 535 | 534 | |
| Dry matter intake (lbs/day) | 16.80[b] | 15.74[a] | -1.06 |
| Gain (lbs/day) | 2.84 | 2.89 | 0.04 |
| Feed conversion (Gain/DMI) | 0.169[a] | 0.183[b] | -0.014 units |

[1] Times in days for silage to rise above ambient temperature.

[a, b] Treatment means within a row significantly different (P<0.05).

With Fiber Technology inoculants, ruminant animals can take advantage of lignin-bound energy, and livestock operations will need less supplemental energy from corn grain, soybeans or some other energy source. Many livestock operations can save a substantial amount of money on rations by dropping the amount of costly supplemental energy feed ingredients they need to provide.

Pioneer offers three products with Fiber Technology: Pioneer® brand 11CFT for corn silage, Pioneer® brand 11AFT for alfalfa silage and Pioneer® brand 11GFT for grass silage.

With high feed costs for animal operations, preserving, protecting and enhancing silage quality is more important than ever. Great silage experiences depend on several key factors: proper silage moisture, elimination of oxygen, efficient reduction of silage pH, aerobic stability and enhanced forage digestibility at feedout, and prevention of losses due to yeasts and molds on feedout. The best way to manage these factors involves checking moisture prior to harvest, good packing, and the use of an *L.buchneri* inoculant.

## References

Adesogan, A., Huisden, M, Arriola, K., Kim, S., Foster, J. 2005. Factors affecting the quality of corn silage grown in hot, humid areas: Effect of applying two dual-purpose inoculants or molasses. JAS, Vol 83, Supp 1/JDS, Vol 88, Supp 1. P 383. Abst. 665.

Addah, W., Baah, J., Okine, E.K. and McAllister, T.A. 2011. A third-generation esterase inoculant alters fermentation pattern and improves aerobic stability of barley silage and the efficiency of weight gain of growing feedlot cattle. JAS, 2011-4085.

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