Kemin Americas, Inc.
2100 Maury Street
Des Moines, Iowa, USA 50317-1100
tel: **515.266.2111** fax: 515.266.8354
www.kemin.com

Technical Literature

Evaluation of Bacteria Species and Enzymes Used in Bacterial Silage Inoculants

Introduction

Silage producers today frequently use bacterial inoculants to supplement their forage with acid-producing bacteria to aid fermentation. Lactic acid is the most commonly identified organic acid that helps reduce the pH in the silage. Therefore, lactic acid-producing bacteria are the primary type of bacteria utilized in most commercial bacterial inoculants. While there are many species of lactic acid producing bacteria, *Lactobacillus plantarum* is the one most commonly found in commercially available bacterial inoculants. However, there are many other bacteria species also used in bacterial inoculants. Although a large body of university and company research supports the use of bacterial inoculants, little can be found comparing the performance of various species of bacteria in inoculants. This paper is intended to give an overview of some of the research comparing various species of bacteria and the addition of enzymes used in inoculants.

Discussion

Lactobacillus spp.

Lactobacillus plantarum is the most widely used bacteria in commercial inoculants. A large body of research demonstrates its performance in improving fermentation properties of ensiled forages. Many commercially available inoculants use *L. plantarum* as the primary bacteria source, while a few use it only as a supplemental bacteria source. Kemin Americas, Inc., research has shown that corn silage inoculated with Kem LAC®$_{brand}$ silage inoculant, which has *L. plantarum* as its primary bacteria source, had a 4.9% improvement in dry matter recovery over untreated corn silage.

Lactobacillus buchneri is another lactic acid producing bacteria that has become popular in many areas as a bacteria source in commercial inoculants. A disadvantage of many bacterial inoculants is their inability to provide aerobic stability when oxygen is introduced to the silage (Muck and Kung, 1997). Under those conditions, *L. buchneri* has shown improved aerobic stability (Kung and Ranjit, 2001). However, a disadvantage to the use of *L. buchneri* as a bacteria source is the amount of bacteria needed to provide aerobic stability. Research shows that at least 500,000 cfu/gram of silage of *L. buchneri* is required to show an effect on aerobic stability (Kung and Ranjit, 2001) resulting in additional cost to the user. Further, silage fermentation from *L. buchneri* is a heterofermentation process, which can result in a longer period of time for silage to become stable and higher dry matter losses.

Pediococcus spp.

Pediococcus spp. bacteria are commonly found in commercial inoculants when *Lactobacillus* spp. are either not used or used as a supplemental bacteria source. Higginbotham et al. (1998) reported that an inoculant containing *P. cerevisiae* as the primary bacteria source and *L. plantarum* as a supplemental bacteria resulted in a decrease of 10.7% in dry matter when compared to untreated corn silage. That can mean a significant drop in the amount of forage available to feed livestock and the potential need to buy supplemental feed. These researchers attributed a portion of this dry matter loss to extensive fermentation due to the initial high moisture content (approximately 77%) of the silage. *Fitzsimons* et al. (1992) concluded that *P. acidilactici* may only be useful as a silage inoculant for crops with a sufficiently high water-soluble carbohydrate level. This would suggest that an inoculant with *P. acidilactici* would not be beneficial in the production of haylage. Cai et al. (1999) reported that silages inoculated with *Pediococcus* spp. bacteria and stored at 118º F were of poor quality after fermentation. Therefore, inoculants containing *Pediococcus* spp. bacteria may not perform effectively in climates with high environmental temperatures.

Propionibacterium spp.

As the name implies, *Propionibacterium* spp. bacteria produce propionic acid rather than lactic acid. However, lactic acid is commonly accepted as assisting most in the fast pH reduction of ensiled feed. Therefore, there could be an extended period of time for the pH to decline and the silage to become stable using bacteria from this species. With extended fermentation time, chances increase for losses to occur due to plant cell respiration and microbial growth. Research has suggested that *P. shermanii* can survive in and improve the aerobic stability of slow fermenting silages that are prone to aerobic deterioration

®™ Trademarks of Kemin Industries, Inc., USA © 2003 Kemin Americas, Inc., USA

(Weinberg et al, 1995). Higgenbotham et al. (1998) reported that corn silage inoculated with a combination of *Pediococcus cerevisiae* and *Propionibacterium acidipropionici* resulted in a 9.7% decrease in dry matter recovery when compared to untreated corn silage. Again, this is a significant drop in the quantity of forage available to feed livestock that can result in the potential need to buy supplemental feed. These researchers attributed a portion of this dry matter loss to extensive fermentation due to the initial high moisture content (approximately 77%) of the silage.

Enzymes

Many producers feel the inclusion of an enzyme in an inoculant can help the fermentation and digestibility of silages. Research conducted by Shepard and Kung (1996) showed that treatment of corn silage with an enzyme additive did not dramatically improve fermentation properties but did reduce NDF and ADF content and improve *in vitro* NDF digestion. In addition, these researchers found that the enzyme additive had no effect on dry matter intake, milk production, milk composition, or feed efficiency. Stoke (1992) reported that a combination of bacteria and enzymes were antagonistic to one another and did not improve silage fermentation, nutritional value, or animal performance when compared to either the enzyme or bacterial inoculant used alone. These researchers concluded that inoculants that contain both enzymes and bacteria must be evaluated carefully to ensure no antagonistic interactions occur and for their cost/value compared to a bacteria-only inoculant.

Conclusions

Using a bacterial inoculant can be an effective management tool for silage producers. *Lactobacillus* spp. bacteria – those most often found in commercially available inoculants -- have shown superior effectiveness in improving silage fermentation characteristics. Because lactic acid is most commonly accepted to drop ensiled forage pH the fastest, inoculants that limit lactic acid production or that primarily produce other organic acids may create unfavorable conditions in the fermentation process and lead to lower overall dry matter recovery. In addition, when considering an inoculant that contains enzymes, producers must consider antagonistic interactions that may occur. Kem LAC®$_{brand}$ silage inoculant contains an optimal blend of lactic acid-producing organisms that have been shown to rapidly decrease silage pH for proper fermentation and high levels of dry matter and nutrient recovery, ensuring the best silage overall.

References:

Cai, Y., S. Kumai, M. Ogawa, Y. Benno, and T. Nakase. 1999. Characterization and identification of Pediococcus species isolated from forage crops and their use for silage making. Applied and Environmental Microbiology. 65:2901-2906.

Fitzsimons, A., F. Duffner, D. Curtin, G. Brophy, P. O'Kiely, and M. O'Connell. 1992. Assessment of Pediococcus acidilactici as a potential silage inoculant. Applied and Environmental Microbiology. 58:3047-3052.

Higginbotham, G. E., S. C. Mueller, k. K. Bolsen, and E. J. DePeters. 1998. Effects of inoculants containing propionic acid bacteria on fermentation and aerobic stability of corn silage. J. Dairy Sci. 81:2185-2192.

Kung, L. and N. K. Ranjit. 2001. The effect of *Lactobacillus buchneri* and other additives on the fermentation and aerobic stability of barley silage. J Dairy Sci. 84:1149-1155.

Muck, R. D. and L. Kung, Jr. 1997. Effects of silage additives on ensiling. Pages 187-199 *in* Silage: Field to Feedbunk. NRAES-99. NRAES, Ithaca, NY.

Sheperd, A. C. and L. Kung, Jr. 1996. An enzyme additive for corn silage: effects on silage composition and animal performance. J. Dairy Sci. 79:1760-1766.

Stokes, M. R. 1992. Effects of an enzyme mixture, an inoculant, and their interaction on silage fermentation and dairy production. J. Dairy Sci. 75:764-773.

Weinberg, Z., G. Ashbell, . Hen, and A. Azrieli. 1995. The effect of a propionic acid bacterial inoculant applied at ensiling on the aerobic stability of heat and sorghum silages. J. of Industrial Microbiology. 15:493-497.