K-STATE
Kansas State University
Research and Extension

FORAGE FACTS

Publication Series

IMPROVING SILAGE QUALITY

INTRODUCTION

Advances in silage technology, which include high-capacity precision chop harvesters, improved silos, polyethylene sheeting, shear-cutting silage unloaders, and total mixed rations, have made silage an important method of forage preservation for beef and dairy cattle producers. Silage quality and nutritional value are influenced by numerous biological and technological factors, including: the crop species, stage of maturity and dry matter (DM) content at harvest, chop length, type of silo, rate of filling, forage density after packing, sealing technique, feedout rate, weather conditions at harvest and feedout, additive use, timeliness of the silage-making activities, and the training of personnel. Because many of these are interrelated, it is difficult to discuss their significance individually. However, there are two dominant features of every silage: (1) the crop, including its stage of maturity and its "ensileability" and (2) the management and know-how imposed by the silage maker.

In "perfect" silage, available carbohydrates are converted by anaerobic bacteria (mainly "homofermentative" lactic acid bacteria) to lactic acid. That lowers the pH rapidly and preserves the silage. In even the best of circumstances, some DM is lost during lactic acid production. But the ensiling process is seldom perfect. Whenever oxygen is present, carbohydrates are converted to carbon dioxide and water, accompanied by the generation of considerable heat. The results are serious DM losses.

SILAGE ADDITIVES

Additives can be divided into three general categories: (1) fermentation stimulants, such as bacterial inoculants and enzymes; (2) fermentation inhibitors, such as propionic, formic and sulfuric acids; and (3) substrate or nutrient sources, such as molasses, urea and anhydrous ammonia.

Perhaps no other area of silage management has received as much attention among both researchers and livestock producers in recent years as bacterial inoculants. Effective bacterial inoculants promote a faster and more efficient fermentation of the ensiled crop, which increases both the quantity and quality of the silage. The bacteria in commercial products include one or more of the following species: *Lactobacillus plantarum* or other *Lactobacillus* species, various *Pediococcus* species and *Enterococcus faecium*. These strains of LAB have been isolated from silage crops or silages and were selected because: (1) they are homofermentative (i.e., ferment sugars predominantly to lactic acid); and (2) they rapidly grow under a wide range of temperature and moisture conditions. Bacterial inoculants have inherent advantages over other additives, including low cost, safety in handling, a low application rate per ton of chopped forage, and no residues or environmental problems.

Enzymes are capable of degrading plant cell walls and starch, which could provide additional sugars for fermentation to lactic acid and increase the nutritive value of the ensiled material. Although enzymes offer potential to improve silage quality, considerable work needs to be done before they will become commonly used additives.

The justifications for using nonprotein nitrogen (NPN) have been prolonged aerobic stability during the feedout phase and the addition of an economical nitrogen source to low-protein crops, such as corn and sorghum. However, major drawbacks to ammoniation are the potentially dangerous volatile and caustic properties of anhydrous ammonia plus the need for specialized application and safety equipment. NPN always acts as a buffer during fermentation, requiring extra lactic acid to be produced to lower the pH enough for preservation. Thus, NPN addition always increases DM loss.

20 YEARS OF SILAGE ADDITIVE RESEARCH AT K-STATE

Results from over 200 laboratory-scale studies, which involved over 1,500 silages and 25,000 silos, indicate that bacterial inoculants are beneficial in over 90 percent of the comparisons. Inoculated silages have faster and more efficient fermentations—pH is lower, particularly during the first two to four days of the ensiling process, and lactic acid content and the lactic to acetic acid ratio are higher than in control silages. Inoculated silages also have lower ethanol and ammonia-nitrogen values compared to untreated silages.

Results from over 30 farm-scale trials, which evaluated 71 silages, show that bacterial inoculants consistently improve fermentation efficiency, DM recovery, feed to gain ratio, and gain per ton of crop ensiled in corn, forage sorghum and alfalfa silages. Applying urea or anhydrous ammonia adversely affects fermentation efficiency, DM recovery, average daily gain, feed to gain ratio, and gain per ton of crop ensiled, particularly for the higher moisture forage sorghums. An additive with a urea-molasses blend had less negative influence on silage preservation and cattle performance than urea or anhydrous ammonia.

Economics of Bacterial Inoculants and NPN Silage Additives. Based upon the results at Kansas State University, a 2- to 4-pound increase in gain per ton of crop ensiled produces $2 to $4 increases in net return per ton of crop ensiled. If producers use NPN, they actually lose $4 to $6 per ton of corn or sorghum ensiled because of the decreased DM recovery, increased feed to gain ratio, and added cost of replacing the loss of volatile nitrogen. These results apply to beef producers who background cattle or grow replacement heifers and to dairy producers who raise heifers.

Selecting a Bacterial Inoculant. The inoculant should provide at least 100,000 colony-forming units of viable LAB per gram of forage. These LAB should dominate the fermentation; produce lactic acid as the sole end product; be able to grow over a wide range of pH, temperature and moisture conditions; and ferment a wide range of plant sugars. Purchase an inoculant from a reputable company that can provide quality control assurances along with independent research supporting the product's effectiveness.

PROTECTING SILAGE FROM AIR AND WATER

Everyone in the silage business acknowledges that sealing (covering) a horizontal silo (i.e., bunker, trench, pile, or stack) ranks high on the troublesome list. Because so much of the surface of the ensiled material is exposed to air, great potential exists for excessive DM and nutrient losses. The extent of these losses in the top 2 to 4 feet, if there is no protection, is far greater than most people realize. A barrier must be built against air and water after the silo filling operation is completed.

Although future technology might bring a more environmentally and user-friendly product, polyethylene is the most effective sealing (covering) material today. After it is put over ensiled forage, the sheet must be weighted down. Tires are the most commonly used weights, and they should be placed close enough together that they touch (about 20 to 25 tires per 100 square feet). In a 1,000-ton bunker silo, an effective seal to protect the top 3 feet of silage can prevent the loss of $500 to $2,500 worth of silage, depending on the value of the crop. The bottom line is that sealing the exposed surface might be the most important management decision in many silage programs.

QUESTIONS AND ANSWERS ABOUT SILAGE

What are the characteristics of a good corn hybrid for silage? A corn hybrid must be capable of producing a high whole-plant dry matter (DM) yield and a high grain to forage ratio in the silage. It also should have a whole-plant DM content of 30 to 36 percent when the kernel is in the 60 to 80 percent milk-line stage of maturity.

How do sorghums compare to corn as silage crops? Grain sorghum compares very favorably to corn as a whole-plant silage. Grain sorghum should be harvested at the mid- to late-dough stage of kernel maturity. It usually has a higher crude protein (CP) content than corn silage, but slightly lower net energy values for beef and dairy cattle.

The agronomic and nutritional quality traits of forage sorghum silages are far more variable than those of whole-plant corn or grain sorghum silages. Therefore, hybrid or variety selection is critical for forage sorghum, and a good rule-of-thumb is to avoid the phenotypic extremes.

Is it better to harvest (ensile) the silage crop too early or too late? For corn, sorghum, and small grain cereals, it is probably better to harvest too early rather than too late, but excessive effluent must be avoided (i.e., do not harvest above 70 to 72 percent moisture). The earlier-harvested silage will have a lower pH, a higher acid content, and the chance of a greater DM loss in the silo than later-harvested silage. The later-harvested crop will be more difficult to chop and pack, and the drier silage will be more aerobically unstable during the feedout phase than earlier-harvested silage.

For field-wilted forages that are more difficult to ensile, it is probably better to harvest too late (i.e., at a lower moisture) rather than too early (i.e., at a higher moisture). When these forages are ensiled too wet, chances are greater for a clostridial fermentation and high butyric acid and ammonia-nitrogen levels in the silage. When wilted forages are ensiled at a lower moisture, they are more difficult to pack and present risks of heat damage (i.e., a decrease in nutrient availability) and a high mold content. Regardless of the length of the field-wilting period, these forages must be cut at the correct stage of maturity.

What is the proper size for a bunker, trench, or pile silo? The tons of crop to be ensiled and the projected tons of silage to be fed daily determine the proper size for a bunker, trench, or pile. The height, width, and depth dimensions should be small enough to allow a rapid progression through the silage mass during the feedout phase. Most silos are too large—they take too long to fill, and the feedout rate is too slow.

How long after filling can the silo be opened for feeding? The fermentation phase should be completed before the silo is opened for feeding. This normally takes two to three weeks after filling. If silage is fed after only a few days in the silo, DM intake is likely to be affected adversely. Inoculants should reduce the time required for the fermentation phase to be completed. Because grasses and legumes usually ferment slower than corn (or sorghum), grass or legume silages should not be fed until at least three weeks after filling.

What are the losses in a very good silage? The losses in a very good silage will range from 5 to 15 percent, whereas the losses in a very bad silage will range from 25 to 50 percent. Loss is defined as the amount of forage DM that is put in a silo minus the amount of silage DM that is removed from the silo and fed. These losses are the result of effluent, respiration, primary and secondary fermentation, and aerobic activity during the storage and feedout phases.

How does the type of silo affect "losses" and "silage quality?" The type of silo does affect "losses" and "silage quality;" however, minimum losses and high quality silage can be achieved in any type of silo—if it is well managed. In general, vertical silos (towers) are more efficient than horizontal silos (bunkers, trenches, piles and bags), and smaller-capacity silos are less efficient than larger-capacity silos (if filling is not delayed and the silage removal rate is not too slow). "Forage in" versus "silage out" losses range from as low as 5 percent to more than 40 percent.

How do I manage the silage "face" during the feedout phase? The silage "face" should be maintained as a smooth surface that is perpendicular to the floor and side walls (in bunker and trench silos). This will minimize the square meters of surface that are exposed to air. The rate of progression through the silage mass must be sufficient to prevent the exposed silage from heating and spoiling. An average removal rate of 8 to 12 inches from the face per day is a common recommendation.

What problems are associated with silage effluent? Silage effluent has a very high biological oxygen demand, and, thus, is an environmental hazard, particularly if it is allowed to enter a watercourse. Most forages that are ensiled below 26 to 28 percent DM can produce effluent during the first few days postfilling. Effluent is very nutrient-rich and contains soluble sugars, nitrogen and minerals.

What is the real cost of silage? A common method of calculating the real cost of silage is to divide the actual cost per ton of forage after the silo is filled by the percent of the silage that is actually removed and fed when the silo is empty. For example, if 1,000 tons of whole-plant corn are ensiled in a bunker silo at a cost of $25 per ton and 900 tons of corn silage are removed and fed, the real cost is $25 divided by 90 percent (.9), which equals $27.78. If only 750 tons of corn silage are removed and fed, the real cost is $25 divided by 75 percent (.75), which equals $33.33.

Contact: Keith K. Bolsen
Professor
Ruminant Nutrition and Forage Preservation
Telephone: 785-532-1222
Fax: 785-532-73-7059
E-mail: kbolsen@oz.oznet.ksu.edu

Kansas State University Agricultural Experiment Station and Cooperative Extension Service
Issued in furtherance of Cooperative Extension Work, acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and U.S. Department of Agriculture cooperating, Richard D. Wootton, Associate Director. All educational programs and materials available without discrimination on the basis of race, color, religion, national origin, sex, age, or disability.