

Understanding and Improving Fermentation in Alfalfa and Grass Baleage

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The ancient Egyptian and Carthaginians are believed to be the first to conserve forage by ensiling it in the absence of oxygen. Though the technique has been refined in the 3500 years since, the basic fermentation process has not changed. Populations of naturally-occurring bacteria on the plant surface can consume some of the readily available carbohydrates and produce organic acids. These organic acids lower the pH of the forage material and prevent fungal deterioration of the product. Fermentation has been used for millennia as a natural method for preserving food. Similar bacterial fermentation occurs when one makes yogurt, sour cream, or pickles.

Baled silage or baleage is a relatively new technique for conserving forage as silage (Fig. 1). The advantage of baleage over hay is that the crop does not have to be completely dried down. This lessens the risk of weather damage between cutting and baling and allows the producer to harvest the crop in a more timely fashion. Losses during the curing, baling, storage, and feeding phases are also each substantially lower when the forage is conserved as baleage rather than as hay.

Of course, this comes at an expense. The cost of the wrapper (generally \$18,000 – 40,000), plastic wrap (usually \$5-10 per ton of DM), and added labor can make this system quite costly. Furthermore, there is an environmental cost for disposal of the plastic. However, the advantage of timely harvest, higher quality, and more palatable forage makes baleage a crucial tool for livestock producers.

The expense of baleage and the higher value of the resulting forage means that producers should focus on improving fermentation and minimizing spoilage. To do this, it is helpful to have a basic understanding of fermentation and how it can be improved. This paper provides the basics about the fermentation process and the key management recommendations that can ensure fermentation is as complete as possible.

AN OVERVIEW OF THE FERMENTATION PROCESS

Fundamentally, silage becomes stable in the absence of oxygen because anaerobic bacteria convert plant sugars and starches into lactic acid (primarily), acetic acid, and other organic acids. After a



Figure 1. Whether in an upright silo (foreground) or baleage bales (background), the ensiling and fermentation process is fairly similar.

few days, the pH of the silage dropped to a point where mold/fungal and bacterial growth is inhibited. Furthermore, the low pH reduces the activity of enzymes associated with undesirable bacteria (e.g., secondary fermentation by clostridial bacteria). A pictorial description of silage fermentation is presented and briefly explained in Fig. 2.

Silage Fermentation

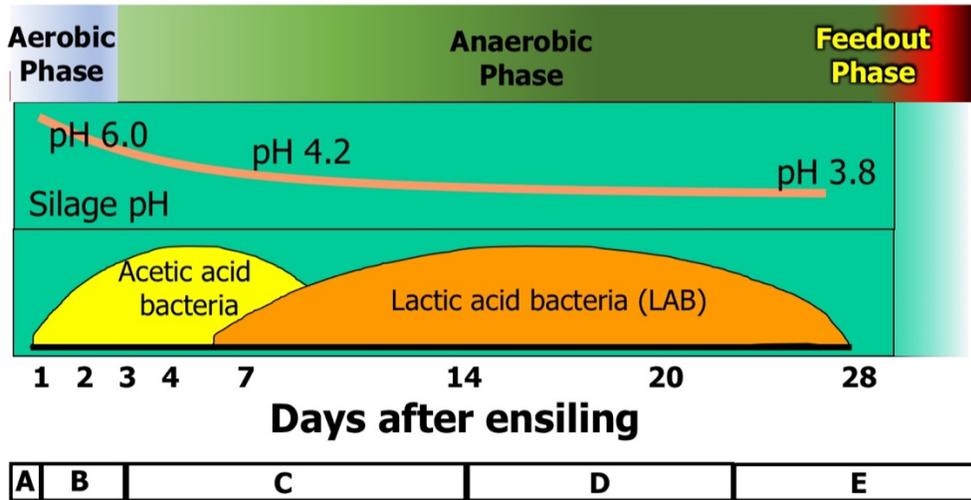


Fig. 2. The phases and segments of silage fermentation. There are basically three phases of silage fermentation: aerobic phase, anaerobic phase, and the feedout phase. (A) In the initial stage of ensiling (i.e., the first 12-24 hours), cell and aerobic organisms consume water soluble carbohydrates and produce CO₂, H₂O, and heat. This can be a significant source of DM loss. (B) Soon, however, heterofermentative bacteria become active. In this stage, acetic and some lactic acid is formed, though some carbohydrates are converted to alcohol and lost. (C) Around this point, the remaining oxygen in the ensiled product is consumed and a transition is made to the anaerobic phase. In the absence of oxygen, there is a transition to more growth by homofermentative, lactic acid-forming bacteria. Once this stage begins, the pH drop becomes more rapid. (D) The activity of the lactic acid-forming bacteria continues and the crop's pH continues to drop until most of the sugar and starch is consumed or the pH gets low enough to suppress even the growth of the homofermentative bacteria. The extent of the pH drop is dependent upon the concentration of fermentable carbohydrates, the moisture of the crop, and the density of the silage crop. (E) Once the pH has dropped, the ensiled crop is stable as long the forage is not exposed to O₂. At some point, the producer begins feeding the crop and O₂ intrusion begins as a result of the seal being broken. Spoilage begins immediately upon O₂ intrusion, but crops that have fermented well may still remain stable for a few hours before decomposition begins. Inoculating with heterofermentative bacteria may reduce the rate of spoilage rate.

BEST MANAGEMENT PRACTICES FOR PROMOTING GOOD FERMENTATION.

In order to promote fermentation and minimize spoilage, there are several crucial steps. These are listed below (not necessarily in order of importance).

- Ensure that adequate moisture (45-60% moisture; 40-65% dry matter) is present to support bacterial growth and the movement of bacteria throughout the crop.
- Prevent excessive moisture (> 65% moisture) in the crop to avoid excessive alcohol production and slowing the transition to homofermentative bacteria. Excess moisture can also result in secondary fermentation (e.g., clostridia, listeria, etc.) which may result in reduced intake or animal poisonings (e.g., botulism, listeriosis, etc.).
- Wrap baleage bales as soon as possible after baling to exclude O₂ as quickly as possible, thereby minimizing heating damage and excessive DM loss.
- Make dense baleage bales so that O₂ intrusion is minimal and heating damage and excessive DM loss is minimized.
- Apply 6 or more layers of plastic on individually-wrapped and 8 or more layers on inline-wrapped baleage bales. If the inline bale wrapper has the capability of applying more plastic at the joints where two bales abut one another, then consider doubling the plastic application at those joints.
- Ensure that the plastic is being pre-stretched by the applicator rollers to the specifications in the wrapper's manual and the plastic manufacturer.
- Add a homofermentative and/or heterofermentative bacterial inoculant to promote more rapid pH drop and/or more stable silage, respectively.
- Be sure to use the inoculant that is labeled for the crop to be ensiled, as these are often strain-specific bacteria.

Avoid mixing the inoculant in chlorinated water and apply inoculant at a rate of at least 100,000 colony forming units/g. Ensure that the inoculant does not heat about 100 °F.

