LITCHFIELD ANALYTICAL SERVICES

P.O. Box 457
535 Marshall Street
Litchfield, MI 49252
Phone: (517)-542-2915 Fax: (517)-542-2014
email: litchlab@qcnet.net web page: www.litchlab.com

Feeds Forages Mycotoxins Soils Plant Tissues Manure Fertilizers Lime Water

The Fermentation Process

The forage goes into the silo as fresh and green as a dinner salad. Presto-Chango – 21 days later it is a deep, rich, brown and smells a lot different. Is it really magic? We'll discuss this magic in a little bit but before we dive deeper, let's get a few definitions under our belt.

Forages are plants such as alfalfa, grasses, corn, or sorghum we feed to cows in fresh, dried, or ensiled forms. Ensiling is the process of preserving a forage crop to store and feed later on. When ensiling, forages are cut, chopped, and placed into bunkers, bags, tower silos, or piles. The stage of maturity at harvest, the method and speed of harvest, the moisture, the ensiling method, and the use of additives all influence the fermentation process and the quality of the resulting silage.

After harvest is complete, the storage container is completely sealed to keep oxygen out and the magic of fermentation begins. Keeping oxygen out is very important to efficiently transform forage into silage. Bacteria in the silo are the magicians responsible for fermentation. Before the forage becomes silage, it undergoes four phases of fermentation over a 21 day period.

Phase 1 -Production of CO2, Heat, & Water

In Phase 1, even though the plants themselves are no longer living after they are cut, cells within the plant are still alive and continue to take in oxygen from the surrounding environment and give off carbon dioxide (plant respiration). Aerobic organisms, which require oxygen to survive, predominate on the surface of the forage particles and also consume oxygen that made its way into the silo before sealing. It if very important that all of the oxygen within the silo is consumed as rapidly as possible since the aerobic bacteria consume soluble carbohydrates that might otherwise be available for the beneficial lactic acid bacteria later in the fermentation process or to the animal consuming the forage.

Although this phase reduces the oxygen to create the desired anaerobic conditions, plant cell respiration produces water and heat in the silage mass. This rise in temperature allows acid-producing bacteria to get to work. Acid-producing bacteria thrive in the silo at temperatures between 80° and 100° F.

If too much oxygen is present after sealing, respiration continues and the forage mass will heat to more than 100° F. Excessive heat build-up can damage the bacteria and greatly reduce the digestibility of nutrients such as proteins.

Another important chemical change that occurs during this early phase is the breakdown of plant proteins. Proteins are first reduced to amino acids and then to ammonia and amines. Up to 50 percent of the total plant protein may be broken down during this process. The extent of protein breakdown (proteolysis) is dependent on the rate of pH decline in the silage. The acidic environment of the silage eventually reduces the activity of the enzymes that break proteins down.

After sealing, there is nothing anyone can do to lower the amount of oxygen in the silo. Phase 1 ends once the oxygen has been eliminated from the silage mass. Under ideal crop and storage conditions, this phase will last only a few hours. With improper management, this phase could continue for several weeks.

The primary objective at ensiling time is to manage the crop so air infiltration is minimized, thereby, shortening the time required to achieve an anaerobic environment. Key management practices are proper maturity, moisture, chop length, and rapid filling with adequate packing and proper sealing of the storage structure.

Phase 2 - Production of Acetic Acid & pH Drop

Once all of the oxygen has been consumed, Phase 2 begins. In Phase 2, anaerobic bacteria, which thrive without oxygen, begin to multiply. Acetic acid-producing bacteria ferment soluble carbohydrates and produce acetic acid as an end product. Acetic acid production is desirable because it can be utilized by ruminants and causes the forage pH to drop from about 6.0 to 5.0. As the pH drops, the acetic acid-producing bacteria decline in number. Known as the "lag phase", Phase 2 typically lasts no more than 24 to 72 hours before Phase 3 starts.

Phase 3 - Lactic Acid Formation

Phase 3 begins as the acetic acid-producing bacteria begin to decline in numbers. When the pH drops below 5.6, lactic acid-producing bacteria begin to thrive. Quality silage is achieved when lactic acid is the predominate acid produced, as it is the most efficient fermentation acid and will drop the pH of the silage the fastest. The faster the fermentation is completed, the more nutrients are retained in the silage. Lactic acid should comprise more than 60 percent of the total silage organic acids produced. When silage is consumed, lactic acid is utilized by cattle as an energy source. Silage with proper lactic acid production is between 4.4 and 5.0 for legume-type crops such as alfalfa and 3.8 to 4.2 for grass and grain crops such as corn silage. Within 14 days, Phase 3 will reach completion and the silage will have a temperature between 80° and 85° F.

Phase 4 - Stabilization

The final phase of fermentation is that stabilization phase. The low pH from the lactic acid production stops all bacteria, both good and bad, from functioning. Stabilization lasts another 5 to 7 days. Experts recommend leaving the silo or bunker closed for at least 21 days after filling.

If the pH is not low enough, or if forages are ensiled at moisture levels greater than 70 percent, a different version of Phase 3 may occur. Instead of lactic acid-producing bacteria thriving, large populations of undesirable bacteria like clostridia may grow and produce butyric acid rather than lactic acid. If butyric acid is produced, the resulting silage is poor quality and has a sour smell. With this type of fermentation, the pH may be 5.0 or higher.

Feed Out & Aerobic Decomposition

Proper feed out procedures are important because research shows that nearly 50 percent of the silage dry matter losses occur from secondary aerobic decomposition. Aerobic decomposition occurs on any surface of the silage that is exposed to oxygen. High populations of yeast and mold or the mishandling of stored forages can lead to significant losses due to aerobic deterioration. Proper management is vital to reduce these losses and improve the bunk life, or aerobic stability, of the silage.

Making Quality Silage

Making forage ferment correctly starts before the forage ever reaches the silo. Each step of the production cycle, including cutting, harvesting, and ensiling, must be carefully orchestrated to allow the bacteria to "work their magic." Carefully working every aspect of the harvesting process helps optimize fermentation and silage quality. Additives can be combined with forages to help lower the pH and discourage undesirable bacteria from producing butyric acid. Some general guidelines to maintain the quality of your forage through effective and efficient fermentation follow:

- **Harvest at the proper stage of maturity.**
  - Alfalfa - mid to late bud stage.
  - Red clover - 1st flower to 10% bloom stage.
  - Grasses - late boot to early head stage.
  - Corn silage - 50 to 67% milk line.
  - Sorghum silage - medium dough stage.
  - Small grain silage - early head stage.
- **Chop at the proper moisture content.**
  - Alfalfa haylage
    - Bunkers – 65 to 70% moisture.
    - Concrete Uprights – 60 to 65% moisture.
    - Oxygen-limiting silos – 50 to 60% moisture.
  - Red clover or grass haylage
    - Bunkers – 67 to 72% moisture.
    - Concrete Uprights – 63 to 68% moisture.
    - Oxygen-limiting silos – 50 to 60% moisture.
  - Corn silage.
    - Bunkers – 67 to 72% moisture.
    - Concrete Uprights – 63 to 68% moisture.
    - Oxygen-limiting silos – 55 to 60% moisture.
  - Small grain silage.
    - Bunkers – 67 to 72% moisture.
    - Concrete Uprights – 63 to 68% moisture.
    - Oxygen-limiting silos – 50 to 60% moisture.
  - Forage sorghum silage.
    - Bunkers – 70 to 75% moisture.
    - Concrete Uprights – 65 to 70% moisture.
    - Oxygen-limiting silos – 50 to 60% moisture.
- **Chop at a proper theoretical length of cut (TLC).**
  - Alfalfa haylage – 0.2500 to 0.375 inch.
  - Red clover haylage – 0.250 to 0.375 inch.
  - Corn silage – 0.375 to 0.500 inch.
  - Small grain silage – 0.250 to 0.375 inch.
  - Forage sorghum silage – 0.375 to 0.500 inch.
- **Fill the silo rapidly & enhance compaction.**
  - Uprights – Top off w/ > 1 feet of wet forage.
  - Bunkers – Compress forage w/ tractor.
  - Bags – Use a good filling machine.
- **Seal silo carefully.**
  - Uprights – cover w/ plastic & seal cracks in walls.
  - Bunkers – Seal cracks in walls. Secure plastic so that air is not drawn into the silage under windy conditions.
  - Bags – Seal carefully and repair damaged bags.
- **Leave silo sealed for at least 21 days.**

We acknowledge and extend our sincere appreciation for the use of information from publications from the following institutions in the development of this paper:

National Forage Testing Association
Hoard's Dairyman Magazine
Michigan State University
Purdue University
University of Wisconsin