COOPERATIVE EXTENSION SERVICE
SDSU

Extension Extra

ExE4032
June 2005
Dairy Science

COLLEGE OF AGRICULTURE & BIOLOGICAL SCIENCES / SOUTH DAKOTA STATE UNIVERSITY / USDA

Heat Damage in Alfalfa Silage

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Differences in maturity of the stand, the weather, and harvesting, storing practices, and facilities affect the successful preservation of alfalfa silage.

Silage fermentation is basically a destructive process, for nutrients are lost through chemical changes. The feeding value of alfalfa silage will always be less than that of the original forage, and the ensiling practices that are used will determine the extent of those losses.

Losses from fresh forage to the ensiled feed arise from one or more of the following: field, oxidation, fermentation, and effluent. Aeration and the heating that results are among the most important causes.

Importance of anaerobic conditions

Respiration and oxidation losses are low when wilting in the field is not extended by adverse climatic conditions and when the silo is filled quickly.

The majority of dry matter losses result from fermentation by the microbial population. Effluent production can also be a significant source of dry matter (DM) losses.

The ultimate objective in preserving good quality alfalfa silage is to achieve anaerobic conditions as fast as possible. The most efficient way is by storing the chopped forage under airtight conditions. The remaining air will be removed early in the fermentation process by the respiratory enzymes of the plant.

Research has shown that 90% of the oxygen is lost within 15 minutes in the silo and that less than 0.5% remains after 30 minutes from the time of sealing. Other reports have shown that oxygen disappeared completely within 5 hours after immediate sealing, whereas 90 hours were required when sealing was delayed for 48 hours.

When sealing of the silo is delayed, or when air leaks into the silage through cracks or during feed removal, growth of aerobic microorganisms increases. These aerobic microorganisms consume readily available nutrients. Losses of sugars, short chain organic acids, starch, and structural carbohydrates occur, and pH and ammonia increase, which reduces both the nutritive value and palatability of the silage.

Another factor influencing silage deterioration is inadequate packing. Air infiltration and packing are inversely related to each other. With adequately packed material only the surface of the silage is spoiled. Chopped forage, more easily packed than intact material, favors fermentation because soluble carbohydrates released from plant cells are utilized as a substrate by anaerobic microorganisms. Chopping the forage is effective in minimizing temperature rise in the silage.

Causes of heat production

Alfalfa is sometimes ensiled at relatively high dry matter content in order to decrease effluent production.

Under these conditions packing cannot be successfully achieved and heating may occur in the silo because of air included in the silage mass.

As silage is then removed for feeding, air easily infiltrates the silage and the temperature of the material increases. The oxidation of sugars releases energy, and although some is used for microbial synthesis, the rest is released in the form of heat.

Oxidation in the silage mass may proceed rapidly. Temperatures of 147 F in alfalfa silage undergoing heat damage on the 12th day following ensiling have been reported.

Heating stops only when the supply of oxygen is exhausted. If air continues to infiltrate the silage, spontaneous combustion may occur. Silages with high dry matter content and/or high amounts of sugars are at greater risk of large increases in temperature during fermentation. A given amount of air in high dry matter silage will produce a larger temperature increase than the same amount of air in wetter silage.

Effects of air infiltration on silage composition

Some dry matter losses are unavoidable even when following good ensiling practices. If the silo is well packed and quickly covered, losses through fermentation and respiration can be as low as 4-6 %.

Increasing the dry matter of the chopped forage through wilting can decrease effluent losses.

Losses also can occur at feed-out. Feed-out losses are caused by aerobic organisms, which utilize dry matter as a source of energy. Continuous oxygen infusion in the silage due to inadequate removal from the face exposed to the air will further increase those losses. Research has demonstrated that storage without airtight conditions can result in dry matter losses that exceed 40%.

At least 10 inches in depth should be removed daily from the exposed face in order to minimize spoilage. The slice removed should be as even as possible across all the front face, avoiding jagged edges and cracks.

Plant cell breakdown and the release of plant juices are prerequisites for the growth of lactic acid bacteria during the early stages of ensiling. Infiltration of even small amounts of air can delay pH drop in the silage.

Both pH and dry matter content are used as criteria for measuring silage quality. In silages with more than 35% dry matter, low pH becomes less critical from the point of view of preservation, as limited availability of water will inhibit proliferation of undesirable bacteria.

Silages that undergo limited fermentation, as measured by pH and acid content, tend to show heat damage more frequently. This is also true for high dry matter silages, which tend to be higher in pH and “brown” more frequently. As dry matter loss increases there is an increase in the pH as a result of losses of sugars that are not available for lactic acid production.

It has been demonstrated that low pH in itself is not enough to prevent aerobic deterioration, as there are yeasts that can grow under acid conditions.

Acidic conditions in ensiled alfalfa also serve a very important function in preserving the integrity of plant proteins. Breakdown of protein in alfalfa silage occurs during the first few days after ensiling mainly due to the action of plant enzymes, and is considered to be minimal after 5 days.

Research has shown that protein breakdown ceases when pH drops below 4.3. From this perspective the rate at which the acid is produced seems to have more influence in decreasing proteolysis than the total amount of acid. Once this plant enzymatic activity ceases, any further protein breakdown and consequent ammonia production is attributed to the action of microorganisms.

Success in conserving alfalfa silage depends on the amount of readily fermentable carbohydrates that are present in the plant. If the concentration is high enough, conditions favor the establishment and growth of lactobacilli. Preservation will thus be successful with the fermentation of these carbohydrates to lactic acid. The rapid proliferation of lactic-acid producing bacteria during the first 3 days of the ensiling process inhibits unwanted types of microorganisms such as clostridia and fungi.

When wilting of the alfalfa in the field is prolonged or air infiltrates the silage mass, excessive oxidation of water-soluble carbohydrates may occur. Although these respiration losses are relatively small as a percent of dry matter, they are large when expressed as a percent of water-soluble carbohydrates. Delaying the sealing of the silo has more effect on fermentation when the water-soluble carbohydrates are relatively low.

In contrast to the water-soluble carbohydrates, structural carbohydrates are generally unavailable to the plant in times of stress and are represented by pectin, hemicellulose, and cellulose. If fermentation in alfalfa silage proceeds normally there should be no change in this fraction. But when temperature in the alfalfa silage increases during aerobic fermentation, the fiber fraction tends to increase.

These changes are attributed to the formation of indigestible nitrogen compounds recovered in the Acid Detergent Fiber fraction. This reaction, also called non-enzymatic browning or Maillard reaction, occurs between nitrogen-containing compounds and sugars, resulting in both being unavailable to the animal. This reaction can be measured by analyzing the silage for its Acid Detergent Insoluble Nitrogen content (ADIN).

Alfalfa silage is more susceptible to heat damage than wetter silages because it dissipates less heat (due to its higher dry matter content), and because less fermentation has taken place and therefore more sugars remain to react with nitrogen-containing compounds.

Follow best management practices for good silage preservation

Optimize animal performance when feeding alfalfa silage by minimizing dry matter losses. This is the key.

Dry matter losses can be significant not only during the ensiling process but also during feed-out. Some guidelines to follow are:

- Chop alfalfa at the right maturity/moisture content (60-65%).
- Fill the silo as soon as possible.
- Achieve adequate compaction (adequate length of cut).
- Cover and seal tightly.
- Allow undisturbed fermentation for 3 weeks.
- Feed-out neatly, taking at least 10 inches in depth from all of the exposed face.

If after following all these recommendations you still end up with dark colored, tobacco-smelling alfalfa silage, it is recommended you run an acid detergent insoluble nitrogen analysis. Based on this analysis the ration should be adjusted for total protein availability.

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ExEx4032, 2005. Access at http://agbiopubs.sdstate.edu/articles/ExEx4032.pdf