Managing Aerobic Stability

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Aerobic instability of silages and high moisture corn at feedout is a common problem. Common symptoms are heating, mold growth, or mustiness occurring on the face or surface. Feeding aerobically unstable materials can reduce feed intake and/or growth or milk production. Each 15ºF increase in temperature in one ton of 30% DM silage requires over 6.3 MCal of energy (Richard Muck, personal communication: assumes core temperature readings in a silage bunker or pile with minimal heat loss), costing around 10 lb in lost milk production per ton of silage. Additionally, feed costs increase due to lost DM and increased refusals. Clearly, preventing aerobic instability is an important aspect of producing high quality forages and ensiled grains for livestock and dairy production.

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Even crops harvested at the optimal maturity, moisture content and chop length can be susceptible to heating and mold growth. Aerobic instability can occur shortly after ensiling, or the crop may appear to ferment well then heat rapidly and spoil at feed-out. Yeasts that naturally occur in all forage and high moisture grain crops are the major cause of aerobic instability. Corn and cereal silage and high moisture corn can have high indigenous yeast populations because yeasts grow best on feeds that contain starch and soluble sugars (Figure 20).

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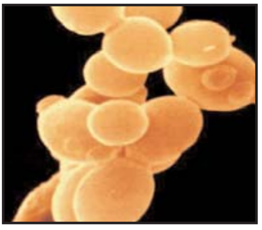
Factors Related to Aerobic Instability

Aerobic instability is usually due to explosive growth of yeasts over a short period of time. Yeasts can multiply rapidly during the first few days after harvest, before all of the oxygen in the ensiled feed is consumed, metabolizing sugars and starches, generating carbon dioxide, water, alcohol and heat. Management practices that reduce exposure to air, such as rapid silo filling and good packing, reduce yeast growth and their negative effects on silage quality. Ensiled crops with greater than 1,000,000 (10^6 CFU/g) yeast per gram typically have a 'yeasty' or alcohol smell will heat and spoil (mold) quickly when exposed to air.

Aerobic instability can also be a problem if feedout rates are not adequate or if ensiled feeds are not consumed within a few hours after removal, especially during warm weather. While some yeasts ferment only sugars, some naturally present on forages and in silages can also metabolize lactic acid, the primary acid produced in silage fermentations. Many microbial silage inoculants contain homo-fermentative lactic acid producing bacteria to increase the production of lactic acid, improve the ensiling fermentation efficiency, and reduce the pH more rapidly. The production of lactic acid is very important but we now know that production of lactic acid alone can actually increase heating and spoilage at feed-out.

Figure 20: Yeasts reproduce by budding, allowing for rapid growth when conditions are favorable.

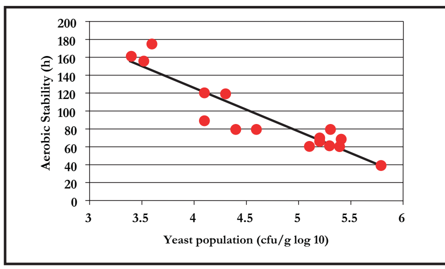


The progression of aerobic instability appears to be as follows:

1. Crops with high natural yeast populations are ensiled.
2. Yeasts grow until oxygen is fully consumed, then become dormant and silage fermentation may continue and produce lactic acid.
3. At feedout, feed is exposed to oxygen.
4. Yeasts begin to grow, usually within a few hours of air exposure.
5. Lactic acid is metabolized by yeasts, resulting in loss of DM and TDN and generating heat.
6. Other silage acids are volatized.
7. Silage pH rises as the acids in the silage are lost.
8. Molds with low oxygen requirements begin to grow.
9. Digestibility and palatability further decline.

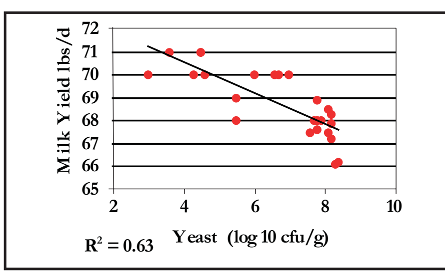
Aerobic stability is measured by speed of heating after exposure to air. University of Delaware researchers (Kung et al., 1998) demonstrated that aerobic stability was negatively correlated to the number of yeasts present at the time the silo was opened (Figure 21). Corn silage with low yeast populations (10^3 CFU/g) remained cool for up to 3 times longer than silages with high initial yeast populations (10^6 CFU/g).

Figure 21: The Effect of Yeast on the Aerobic Stability of Corn Silage



(Kung et al, 1998)

Figure 22: Milk Production Losses Feeding Aerobically Unstable High Moisture Corn



(Hoffman and Ocker, 1997)

Aerobic instability increases nutrient losses in feed and reduces feed intake and production of dairy cattle (Hoffman and Ocker, 1997) and beef cattle (Whitlock et al., 2000). Cows fed high moisture corn from a 14 day supply of high moisture corn removed all at once from a silo, kept in a loose pile and fed daily showed a declining milk yield as the level of yeasts in the pile rose (Figure 22). Cows fed material removed from the silo daily were unaffected. Intakes were not affected. Over 14 days lactic acid declined and pH and mold growth increased in the corn that had been piled. This suggests that the energy content of the corn declined as it became progressively more unstable, which in turn reduced milk output. Intake may have been unaffected because the corn was blended with fresh forages immediately before feeding.

Good harvest and management practices that reduce exposure to air are critical. In addition, certain additives can also help to improve aerobic stability. Management practices generally do not eliminate yeasts but reduce their ability to grow.

1. Proper silage management

Reducing economic and nutritional losses due to aerobic instability starts with good silage management. Harvesting at proper moisture levels, rapid harvest and filling, extensive packing and the use of plastic covers, are all important and necessary to exclude oxygen. Limiting exposure of the feed to oxygen promotes rapid acidogenic fermentation, reducing time in which yeast and mold populations can grow. Practical aspects of employing all of the best silage management techniques are often challenging and even when perfectly executed, aerobic instability can still sometimes occur due to the high indigenous yeast levels on the crop at harvest.

2. *Lactobacillus buchneri*

In numerous research trials *L. buchneri* 40788 has been shown to dramatically improve aerobic stability by inhibiting the growth of yeasts. Recent work at the University of Delaware (Kleinschmit et al., 2005) and USDA research (Table 15) indicate that inoculation of corn silage with the FDA recommended rate of 4×10^5 CFU/gram *L. buchneri* 40788 is one of the most consistent additives for improving aerobic stability.

Table 15: Effect of *L. buchneri 40788* on Aerobic Stability of Corn Silage

Treatment	Stability, hr*
Control	75
Inoculant 1	91
Inoculant 2	71
Inoculant 3	50
L. buchneri 1	217
L. buchneri 2	178
Inoculant + sodium benzoate	151

**Time required for corn silage temperature to rise 2 C.* (Muck 2004)

Lactobacillus buchneri is a hetero-fermentative bacterium that produces both lactic and acetic acids during fermentation. While lactic acid can be used as a food source by some common silage yeasts, acetic acid is a potent inhibitor of mold and yeast growth (Danner et al., 2003). When applied at the time of ensiling, *L. buchneri* 40788 has been shown to increase aerobic stability of high moisture corn (Taylor and Kung, 2002, Kendall et al, 2002)), corn silage (Kleinschmit et al. 2005), alfalfa silage (Kung et al, 2003), small grain silages (Taylor et al. 2002), grass silage (Driehuis et al., 1996) and sugar cane silage (Pedroso et al, 2002) and to prevent spoilage in dry baled hay (Baah et al., 2005).

Feeds inoculated with *L. buchneri* 40788 also appear to improve aerobic stability of the rations they are mixed into. Combs and Hoffman (2003) found that a total mixed ration (TMR) containing corn silage and high moisture shelled corn inoculated with *L. buchneri* 40788 remained stable nearly 30 hours longer than a TMR containing untreated corn silage and high moisture corn.

Using *L. buchneri* in a silage management program is of most benefit where problems with aerobic instability are expected. Corn silage, small grain silages, and high moisture corn are more susceptible to spoilage once exposed to air than legume silages. Other situations that favor the use of *L. buchneri* are feeding ensiled feeds during hot weather, low feed removal rate, when it is known that the silage will be moved (e.g. from bag to tower or when silage is sold) or in situations where silages treated with lactic acid-producing bacteria have a history of heating before feedout.

Acetic acid in silages has often been associated with reduced feed intake in ruminants. Research at the University of Wisconsin (Combs and Hoffman, 2003) and the University of Delaware (Ranjit et al., 2002) showed that while feeds inoculated with *L. buchneri* 40788 had higher concentrations of acetic acid and were more stable than the untreated corn silage or high moisture corn, milk production and feed intake were not affected.

3. Organic Acids

Organic acids, e.g. propionic, acetic and benzoic acids, can be applied to control aerobic instability using one of two strategies.

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The first is to apply high rates of the acid to achieve complete preservation. To be effective, 10 to 20 lbs active ingredient (AI) of organic acids are required per ton of feed ensiled.

The second strategy is to apply organic acids at low rates (2 to 5 lbs AI per ton) at ensiling to control yeast populations at feed out. These rates do not provide full preservation and the material is still dependent on normal fermentation. Therefore, it is advised to use an inoculant at ensiling to help ensure adequate fermentation. The organic acid and the inoculant can not be mixed, leading to practical application issues, and using both an organic acid and an inoculant significantly increases production costs. Research studies comparing corn silage or high moisture corn normally fermented or treated with organic acids have shown no differences in palatability, intake, or animal performance.

4. Anhydrous Ammonia

Anhydrous ammonia can also be used to control aerobic stability in silages: use on high moisture corn is not recommended due to the low moisture content. Anhydrous ammonia is a very effective anti-fungal agent and can dramatically reduce yeast and mold populations in silages. It does, however, alter the fermentation: it is basic in nature and immediately after application elevates the pH. Thereafter the pH slowly declines via a stilted, slower and less extensive fermentation. Some research has shown associated elevated fermentation DM losses, though anhydrous ammonia treatment often improves aerobic stability and lowers DM losses at feed out. To be effective, it is applied at 6 to 8 lbs per ton of silage and its caustic nature requires specialized handling equipment. Application is dangerous and should only be done by skilled personnel with proper safety equipment.