

# Improving the aerobic stability of silages

**M**ICRO-ORGANISMS involved in the ensiling process include beneficial bacteria (homolactic acid bacteria), detrimental bacteria (for example, *clostridia*) and unwanted yeasts and moulds.

In a good silage pit (or bun), air is eliminated by respiration from the plant and packing, thus preventing the growth of detrimental aerobic microbes.

When air is eliminated from the silo, production of acid begins and a low pH eventually curtails the growth of all bacteria.

A limited amount of heating during the early days of ensiling is good because it is an indication that bacteria are starting to ferment the silage.

However, heating for prolonged periods of time is an indication that there was too much air in the silage mass.

Excessive heat can result in heat-damaged proteins, low energy values, and low dry matter recoveries. Preventing silage from spoiling can improve the efficiency of a feedlot by preserving forage as high quality silage that is palatable to cattle.

## Aerobic stability

When fermentation is completed, and silage is exposed to air during feedout or during storage (eg leaky silos, holes in bag silos, poorly packed silage), heating in the silo and feed bunk is usually initiated by yeasts that assimilate lactic acid. Moulds and aerobic bacteria (eg bacilli) are often secondary contributors to the spoilage process. (Woolford, 1990).

Aerobic stability is a term that nutritionists have used to define the length of time that silage remains cool and does not spoil after it is exposed to air.

Silages that are aerobically stable are good. In general, silages that spoil rapidly when exposed to air have large amounts of yeasts (more than 100,000 to 1,000,000 yeast colonies per gram of wet silage); those with low levels of yeasts (less than 100 to 10,000 yeast colonies) often remain stable for prolonged periods of time.

Ironically, silages that have undergone clostridial fer-



mentation are very stable when exposed to air because they have high concentrations of butyric acid that is highly antifungal.

However, clostridial silage is undesirable because loss of dry matter and nutrients are extremely large when this type of fermentation occurs.

Silages that have a strong vinegar smell (acetic acid) ▶

A black and white advertisement featuring a close-up of a cow's face on the left. The text 'TYLECO' is written in large, bold, white letters across the middle, with 'THE ALTERNATIVE TO TYLAN' written below it in smaller white letters. A small Australian flag is in the top right corner of the ad.

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are also usually very stable when exposed to air because acetic acid is very toxic to yeasts and moulds. Naturally occurring levels of propionic acid in silages are probably too low to help much in reducing aerobic spoilage.

Because air fuels the growth of yeast, minimising air in silage is an important goal in silage making.

Harvesting forages at optimum moisture levels (not too dry), correct particle size (not too long or short), filling and *sealing* quickly and feeding out adequate amounts of silage from the silo each day will help to minimise silage's exposure to air.

Clean and efficient removal of silage from the face of bunkers will also help to minimise spoilage.

Poor aerobic stability is often worse in high moisture corn, corn silage, and cereal silages than in alfalfa silage.

High ambient temperatures will also stimulate the growth of aerobic spoilage microbes.

If heat is detected in silage months after silo filling, this is usually an indication of spoilage and reduced nutritive value. Depending on the degree of spoilage, cattle may eat less feed and/or gain more slowly.

### Improving aerobic stability with chemical additives.

There are many chemical-based products available to silage managers that claim to improve silage quality.

Most of these products contain buffered propionic acid as the primary active ingredient.

These preservatives may also contain other antifungal compounds such as sorbic acid, benzoic acid, and acetic acid.

Buffered propionic acid-based products are generally non-corrosive and safe to handle. Label recommendations for most buffered propionic acid products range from 1-3 litres/tonne of forage.

As expected, research suggests that higher application levels are better than lower (Kung et al, 1998, 2000).

A less commonly used additive to control yeasts and molds in silage is anhydrous ammonia (2.5-3 kg/tonne) (Kung et al, 2000). The major drawback with ammonia is operator safety during application.

### Improving aerobic stability with *Lactobacillus buchneri* 40788

Bacterial inoculants, based on homofermentative lactic acid bacteria, have been added to silages to improve fermentation and increase dry matter and energy recovery.

However, lactic acid by itself is a poor antifungal agent. In fact, research data has shown that homolactic acid based silage inoculants often have no effect on aerobic stability or can make aerobic stability worse. (Muck and Kung, 1997).

*Lactobacillus buchneri* 40788 (LB 40788) was identified as having potential to improve the aerobic stability of silages by Richard Muck of the USDA Dairy Forage Research Center, Madison, Wisconsin when he was on a research sabbatical in the Netherlands (Muck, 1996).

Unlike most microbes found in silage inoculants that are homolactic acid bacteria, LB 40788 is a heterolactic acid bacterium.

This microbe partially converts some of the lactic acid in silage to acetic acid, 1, 2 propanediol, and ethanol (Oude-Elferink et al, 2001).

Propionic acid is also sometimes found in silages treated with LB 40788. Other antifungal compounds may also be produced as well.

Both acetic and propionic acid are more effective at reducing the growth of yeasts and molds than is lactic

acid. Thus, research studies have shown that silages treated with *Lactobacillus buchneri* 40788 remain unspoiled for much longer periods of time than untreated silage when exposed to air (Table 1).

Specifically, LB 40788 has improved the aerobic stability of corn (Ranjit et al, 1999), barley (Kung and Ranjit, 2001), alfalfa (Taylor et al 2001b), and wheat and sorghum silages (Weinberg et al 1999). *Lactobacillus buchneri* 40788 has also improved the aerobic stability of high moisture corn (Taylor et al, 2000).

In the past, it might have been heresy to think of using a heterolactic acid bacteria as a silage inoculant.

However, research suggests that concerns about greater DM loss in the silo and reduced intake due to high levels of acetic acid are unfounded.

Studies conducted with LB 40788 have shown that sometimes the loss of dry matter in the silo is slightly more than in untreated silage.

However, these losses have been small (1% to 3% greater). The potential for sparing greater spoilage losses during storage and feedout outweighs the small losses that might be incurred as a result of the fermentation.

Feeding lactating cows silages treated with LB 40788 have also shown that DM intake is not reduced when lactating cows are fed LB 40788 (Driehuis et al, 1999; Taylor et al, 2001a).

These results reinforce the fact that the production of acetic acid via conversion of lactic to acetic acid by LB 40788 (Oude Elferink et al, 2001) is different from the normal pathways of acetic acid production in silage.

The effect of LB 40788 on converting lactic to acetic acid in silages is slow.

Typically, increases in acetic acid will not be observed until silage has cured for at least 40 to 60 days.

Silage pH is usually higher in silage treated with LB 40788 because of the acid conversion. Thus, the ratio of lactic to acetic acid is lower than normal.

In fact, these ratios may be below 2 and there may even be more acetic than lactic acid in some LB 40788 treated silages.

If yeasts and molds are enumerated in treated silages, their numbers will be extremely low (by 100 to 1000-fold). Silage treated with LB 40788 removed from silos will be cool and bunk life will be very good in hot weather.

Research (Ranjit and Kung, 2000) has shown that in typical crops and conditions in the US, LB 40788 must be applied at a rate to achieve more than 200-300,000 colony forming units per gram of wet forage to have consistent effects.

This is higher than the recommended application rate of 100,000 colony forming units per gram of wet forage for traditional homolactic acid microbial inoculants.

**Table 2. Chemical (DM basis) and aerobic stability of untreated high moisture corn and high moisture corn treated with *Lactobacillus buchneri* 40788 (LB) after 166 days of ensiling.**

| Item                 | Control           | LB                |
|----------------------|-------------------|-------------------|
| DM, %                | 73.5              | 73.3              |
| pH                   | 3.94 <sup>b</sup> | 4.15 <sup>a</sup> |
| Lactic acid, %       | 1.05 <sup>a</sup> | 0.73 <sup>d</sup> |
| Acetic acid, %       | 0.36 <sup>b</sup> | 1.19 <sup>a</sup> |
| Aerobic stability, h | 84 <sup>b</sup>   | 450 <sup>a</sup>  |

<sup>ab</sup>Means in rows with unlike superscripts differ  $P < 0.05$ . (From Taylor et al., 2000)

**Table 1. Effect of treating corn silage with *Lactobacillus buchneri* 40788 (LB) on silage fermentation and aerobic stability.**

| Item                             | Control           | LB                |
|----------------------------------|-------------------|-------------------|
| DM, %                            | 37.4              | 38.5              |
| pH                               | 3.71 <sup>b</sup> | 3.82 <sup>a</sup> |
| Lactic acid, %                   | 6.74              | 6.24              |
| Acetic acid, %                   | 2.34 <sup>b</sup> | 5.33 <sup>a</sup> |
| Yeast, log <sub>10</sub> , cfu/g | 5.15 <sup>a</sup> | 0.30 <sup>b</sup> |
| Aerobic stability, h             | 38 <sup>b</sup>   | >572 <sup>a</sup> |

<sup>ab</sup>Means in rows with unlike superscripts differ  $P < 0.05$ . (From Ranjit et al., 1999)

### When should we consider using *Lactobacillus buchneri* 40788

*Lactobacillus buchneri* 40788 should be used in cases where aerobic stability is a problem. For example, bunk, pile or pit silos with large exposed surfaces are good candidates for treatment with LB 40788.

If spoiling silage occurs only during warm weather, treating only the portion of silage that would be fed during that time of the year may be an option (this may be more difficult to do in a bunk rather than tower or bag silo).

Feed targeted for summer feeding, silage moved from one silo structure to another and or silage fed from intermediate feeding piles should be considered for treatment with LB 40788.

### The future of silage inoculants: help at both ends

Watch for combination products that will contain homolactic acid bacteria and *Lactobacillus buchneri* 40788.

Such products will help at the front end of silage fermentation and at the back end during storage and feedout.

### Summary

Heating and spoiling silage is undesirable because of ▶

**Table 3. The effect of feeding alfalfa silage treated with *Lactobacillus buchneri* 40788 on silage end products, aerobic stability of the total mixed ration<sup>1</sup> (TMR), and performance of lactating cows.**

| Item                      | Control           | <i>Lactobacillus buchneri</i> 40788 <sup>2</sup> |
|---------------------------|-------------------|--|
| <b>Silage</b>             |                   |  |
| DM, %                     | 43.4              | 41.5   |
| pH                        | 4.36 <sup>b</sup> | 4.66 <sup>a</sup>                                |
| Lactic acid, %            | 6.58 <sup>a</sup> | 5.25 <sup>b</sup>                                |
| Acetic acid, %            | 3.35 <sup>b</sup> | 5.67 <sup>a</sup>                                |
| <b>Total mixed ration</b> |                   |  |
| Aerobic stability, h      | 68                | 100  |
| <b>Lactation data</b>     |                   |  |
| DM intake, kg/d           | 25.1              | 25.4   |
| Milk production, kg/d     | 39.9 <sup>b</sup> | 40.7 <sup>a</sup>                                |
| Milk fat, %               | 3.37              | 3.43   |
| Milk protein, %           | 3.07              | 3.27   |

<sup>ab</sup>Means in rows with unlike superscripts differ  $P < 0.05$ .

<sup>1</sup>The total mixed ration contained 32% alfalfa silage (control or treated), 11% corn silage (untreated), 5% alfalfa hay, and 52% concentrate.

<sup>2</sup>Added to achieve  $4 \times 10^5$  cfu/g of fresh forage.

(From Taylor et al., 2001).

◀ losses in nutrients and lowered animal performance. Producers should work with their nutritionists and silage consultants to evaluate their specific problems in this area. Proper sizing and maintenance of silage pits and proper harvesting, filling and sealing of silos should be emphasised.

*Lactobacillus buchneri* 40788 is a new silage inoculant based on a completely different set of principles (ie production of acetic acid) that should be considered when producers need to improve the aerobic stability of silages.

**Questions and answers on *Lactobacillus buchneri* 40788**

**What is aerobic stability?** Aerobic stability describes the ability of a silage to remain stable (and not spoil) when exposed to air. A simple method to measure aerobic stability is to expose silage to air and measure the generation of heat.

Heat is produced from spoilage organisms (usually yeasts) that degrade the nutrients in silage. As an example, good quality silage that is stable for 50 hours is better than one that spoils after 10 hours of exposure to air.

**Is the aerobic stability of silage important?** When silages are exposed to air, yeasts can degrade lactic acid, which increases the pH and leads to spoiling. Spoiled silage is especially bad when fed to ruminants because it is low in nutritive value and dry matter intake can be severely reduced.

Aerobic spoilage in the silo may also lead to the production of mycotoxins, which can adversely affect the animal.

**When is aerobic stability of silages a problem?**

Some heat occurs from the natural process of fermentation and this should not be confused with heating from spoilage. However, extensive and prolonged heating during the early period of ensiling may be a result of excess air trapped in the forage mass.

**Are some crops more prone to aerobic spoilage?**

Yes. Silages that contain large amounts of starch – such as corn and barley silage – tend to spoil more readily.

Very dry silages also spoil more quickly when exposed to air than those with a higher moisture content. High moisture corn also tends to spoil rapidly when exposed.

**What can improve the aerobic stability of silages?**

Wilting to the proper moisture content for the specific crop and silo, correct chop length, rapid filling, good packing, and immediate sealing of silos will help to prevent excess air from spoiling silage.

Good bunker face management and feedout rate can also help to keep silages from spoiling.

**What silage additives improve the aerobic stability of silages?**

Organic acid-based additives applied at the time of ensiling at 0.5 to two kilograms per tonne of fresh forage can help to improve the aerobic stability of silages.

Anhydrous ammonia can be used on corn silage to improve its aerobic stability. Traditional microbial inoculants improve fermentation but do not consistently improve the aerobic stability of silages. However, several new products contain microbes that specifically improve the aerobic stability of silages. One of these microbes, *Lactobacillus buchneri* 40788 has markedly improved aerobic stability in silages. 🐾

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