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Cost of silage shrink should be communicated

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ONE of the few silver linings associated with low milk prices is renewed interest in improving the efficiency of the entire feeding process.

This includes reducing feed shrinkage caused by wind, rodents, heating, spoilage and feed bunk refusals.

Some losses are readily noticeable, such as corn meal being wind blown when filling mixer wagons. Other losses, such as silage shrink (dry matter loss), are more insidious. The relatively inconspicuous nature of silage shrink is evident when the wide range in shrink loss estimates provided from queried livestock producers is considered.

This column will attempt to detail the biology and nutritional cost of silage shrink losses.

Fermentation principles

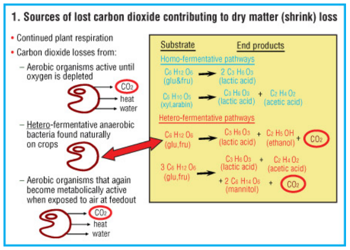
Silage fermentation can be simplified into three phases. Silages experience aerobic conditions during harvest and filling, followed relatively quickly by anaerobic conditions that initiate pH decline. Finally, aerobic conditions return again during feedout.

Dry matter loss (shrink) begins with plant cell respiration and aerobic microflora utilizing carbohydrate sources (primarily sugar) to produce water, heat and carbon dioxide (Figure 1). It is this carbon, lost to the atmosphere, that causes shrink loss.

These processes will continue until the oxygen in the silage mass is depleted. The speed of harvest, wilting (if utilized) and filling are the primary drivers of these losses. However, adequate moisture to reduce silage porosity and adequate compaction also play a role in reducing the length of this initial aerobic phase. An estimate of the loss of net energy (in pure starch equivalents) from this initial aerobic activity is 1-2%, and the loss is largely unavoidable (Woolford, 1984).

The subsequent anaerobic conditions establish an environment suitable for domination by homo-fermentative and hetero-fermentative lactic acid bacteria (LAB). There would be no shrink loss in this phase if only homo-fermentative LAB were active (Figure 1). However, that is not the case as less than 0.5% of epiphytic organisms found naturally on fresh crops are LAB, and only a small proportion of these are homo-fermentative LAB (Lin et al., 1992).

To put the loss from hetero-fermentative LAB in perspective, there is a 24% loss of dry matter from the hetero-fermentative fermentation of glucose (Woolford, 1984). The average net energy loss (in pure starch equivalents) from epiphytic LAB fermentation is 4% (Woolford, 1984). These anaerobic fermentation losses can be reduced by 25% or more with the use of homo-fermentative strains found in reputable silage inoculants (Dennis, 2010).


1. Sources of lost carbon dioxide contributing to dry matter (shrink) loss

The re-exposure of silage to aerobic conditions can be divided into two areas: (1) top and side exposure during storage and (2) face exposure during feedout. The combination of these two sources of shrink loss can vary significantly due to management levels, but estimates of more than a 20% loss in net energy (in pure starch equivalents) have been reported from aerobically unstable silages (Woolford, 1984).

More than 20% of the silage will be contained in the top 3 ft. of many bunkers and drive-over piles.

One of the classic studies regarding top spoilage was conducted by Kansas State University researchers (Dickerson et al., 1990) whose survey work included 30 covered and uncovered bunkers in western Kansas.

Given that most producers today cover their bunkers, it is still of interest that the five covered bunkers averaged 27% organic matter loss in the top 18 in. and another 2% loss in the 18-36 in. zone.

This research team also developed an interesting model system to show the value of covering bunkers using alfalfa silage ensiled in covered or uncovered 55 gal. drums.

In a subsequent study, Kansas State researchers showed that dry matter intake, nutrient digestibility and the integrity of the rumen mat were linearly decreased as increasing levels of spoiled corn silage were purposely incorporated into the normal corn silage rations fed to cannulated steers (Whitlock et al., 2000).

The recent introduction of oxygen-barrier film has certainly been a tremendous step forward in reducing the problem of top spoilage.

A more pressing problem today, however, is managing shrink on the wide, exposed silage faces that are common on large bunkers and piles.

As a comparative, silage bag research at the University of Wisconsin (Muck and Holmes, 2001) showed that relatively well-compacted, 8-9 ft.-diameter silage bags incurred a 9.7% total shrink loss. I often think of this study when producers try to convince me that they have less than 10% shrink while standing in front of piles with 60-80 ft. faces.

Two recent advances have certainly helped reduce aerobic face losses: mechanical facers and inoculants containing *Lactobacillus buchneri* strains that have been proven to reduce yeast growth.

The fact that *L. buchneri* is a hetero-fermentative LAB may lead to questions as to why inoculant manufacturers would use an LAB that is known to be less efficient at fermentation than homo-fermentative strains. The quick answer is that "back-end" aerobic losses are a much larger source of shrink loss in large bunkers and piles, and *L. buchneri* strains effectively limit the yeast growth that initiates the cascade of events leading to silage heating.

In addition, most products containing *L. buchneri* also contain homo-fermentative strains to facilitate a rapid, "front-end" decline in silage pH.

Research from Wisconsin that addressed not only silage density but the porosity of silages (with the goal of less than 40% porosity) also serves to help producers target harvest moistures that will reduce air penetration into the exposed face of large bunkers and piles (Holmes, 2009).

Shrink costs

Producers might have more respect for the importance of shrink loss if they had a better perspective on what it was costing them. They may not fully realize that shrink literally consumes their most valuable silage nutrients that, thus, must be replaced with an equal energy source such as corn grain.

I often try to help producers visualize how many bushels of corn equivalents per ton of silage are being wasted due to shrink. For example, even in a relatively well-managed bunker, if management changes could reduce shrink by 25% (from 15% to 11.25%), that is the same as adding 0.8 bu. of corn to every wet ton of silage fed.

The Table provides a handy example of putting a dollar value on shrink loss based upon the current value of corn grain.

Worth 1,000 words

All producers are keenly aware of the losses they observe from top or side spoilage. However, they may need additional convincing as to the loss in feed value in what may appear to be "normal" silage.

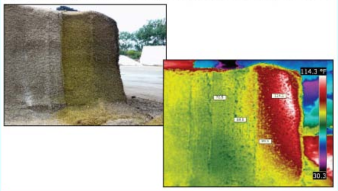
What does not work very well for convincing producers that shrink is a real issue is relying on truck weights into the bunker against total mixed ration weights out of the bunker. That just leaves too much room for measurement errors, and the approach does not account for the biological fact that silage comes out of the storage structure higher in moisture content than when it was ensiled.

However, there are several approaches that can be used to convince producers of the nutritional cost of shrink. One is the use of ash, pH and temperature measurements of silage on the bunker face compared to a deeper-probed (e.g., 20 in.) sample.

In a 2003 Idaho field study of 12 non-inoculated bunkers and piles conducted by Pioneer researchers, the average ash, pH and temperature were 0.27% units, 0.3% units and 12.9 degrees F higher for the face compared to the deep-probe sample. When the ash data were inputted into an organic matter recovery equation developed by Ashbell et al. (1990), it estimated a 5.6% higher organic dry matter loss in the surface silage, presumably from aerobically induced instability (Seglar, 2003).

Totally replacing the lost organic matter with corn starch would require more than a bushel of corn for every ton of silage fed.

2. Normal and thermal-sensitive images of a well-managed, split-corn silage bunker showing heat produced from air penetration



Another less analytical but highly effective approach is the use of a thermal-sensitive camera to help producers visualize the heating caused by aerobic microbial activity.

Figure 2 shows a very well-managed bunker that utilized a mechanical facer. The bunker was split down the middle because it was excessively wide, and the producer routinely sprayed the exposed side face with propionic acid. However, it is apparent that air is penetrating the silage mass, and the resultant increase in temperature is indicative of nutrient loss to aerobic microbes.

The Bottom Line

It makes little sense for producers to invest in superior plant genetics and incur the cost of growing and harvesting if they are then going to allow poor fermentation to rob them of the most energetic constituents in their silage.

The nutritional community needs to increasingly sensitize silage producers to the true cost of shrink by valuing it against an equal energy source such as corn meal.

Recent technological advances can reduce shrink losses. Such advances include having a better understanding of the role of harvest moisture and silage porosity, oxygen-barrier film, mechanical facers and inoculants containing both homo-fermentative and *L. buchneri* strains.

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Cost of dry matter shrink per ton when replaced with corn grain as an equivalent energy source

Corn cost,	**-Shrink, %-**								
$/bu.	**10.0**	**12.5**	**15.0**	**17.5**	**20.0**	**22.5**	**25.0**	**27.5**	**30.0**
3.00	3.78	4.73	5.67	6.62	7.56	8.51	9.45	10.40	11.34
3.50	4.41	5.51	6.62	7.72	8.82	9.93	11.03	12.13	13.24
4.00	5.04	6.30	7.56	8.82	10.08	11.34	12.61	13.87	15.13
4.50	5.67	7.09	8.51	9.93	11.34	12.76	14.18	15.60	17.02
5.00	6.30	7.88	9.45	11.03	12.61	14.18	15.76	17.33	18.91
5.50	6.93	8.67	10.40	12.13	13.87	15.60	17.33	19.07	20.80
6.00	7.56	9.45	11.34	13.24	15.13	17.02	18.91	20.80	22.69
6.25	7.88	9.85	11.82	13.79	15.76	17.73	19.70	21.66	23.63
6.50	8.19	10.24	12.29	14.34	16.39	18.43	20.48	22.53	24.58

Example: Reducing silage shrink from 15.0% to 12.5% is worth $1.11 per ton ($6.62 - $5.51) when the dry matter loss is replaced with corn valued at $3.50/bu.