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QUALITY HAY CROP SILAGE

(Replaces Factsheet "Heat Damage in Hay-Crop Silage," January 1976)

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The greatest amount of high quality protein and available energy in forage can be preserved by understanding and managing both harvest and storage losses. The degree of these two losses is primarily affected by the dry matter content of the forage. Wilting to higher dry matter levels results in higher harvest losses but lower storage losses (Figure 1). Field cured hay has the highest harvest loss but lowest storage loss. On the other extreme, direct cut silage has the lowest harvest loss and highest storage loss. Farmers generally switch from hay to hay silage to reduce in-field drying time, thus reducing or avoiding costly weather damage. However, it is important for a farmer to consider both field losses and storage losses when choosing the correct silage system for his operation.

Five types of storage losses are associated with silage systems. Respiration losses occur when plant cells continue to breakdown carbohydrates and sugars due to excessive amounts of air present in the silage. Fermentation losses result from excessive breakdown of sugars by yeasts and molds contained on the plant material. The main breakdown product of both these losses is carbon dioxide along with water and heat. Seepage losses result when excessively wet silage compresses the silage mass forcing moisture out of the silo. This seepage carries carbohydrates and other nutrients with it. Surface spoilage is another loss which occurs when the less compacted silage in the upper portion of the silo is exposed to air. Finally, there is heat damage which is mainly a quality problem with dryer silages reducing protein availability.

Figure 2 shows the types and degrees of both field and storage losses associated with various silage systems. It should be noted that measuring all such losses is difficult and the figures shown do not reflect all situations. Research at the University of Wisconsin found an average of 9% dry matter loss in concrete silos filled with alfalfa-grass hay silage. Oxygen limiting silos containing similar material suffered 7% dry matter losses indicating that with proper management, losses can be held to nearly the same level in concrete tower silos as in oxygen limiting silos. Other tests and field experience have indicated that it is possible to make good quality silage in a horizontal silo, but only with excellent management. Figure 2 indicates the importance of covering horizontal silos to avoid excessive dry matter losses often associated with this silage system.

Heating Damage

Silage losses can be measured in terms of quantity (weight loss) and quality (feeding value). The fact that some silages may experience little dry matter loss does

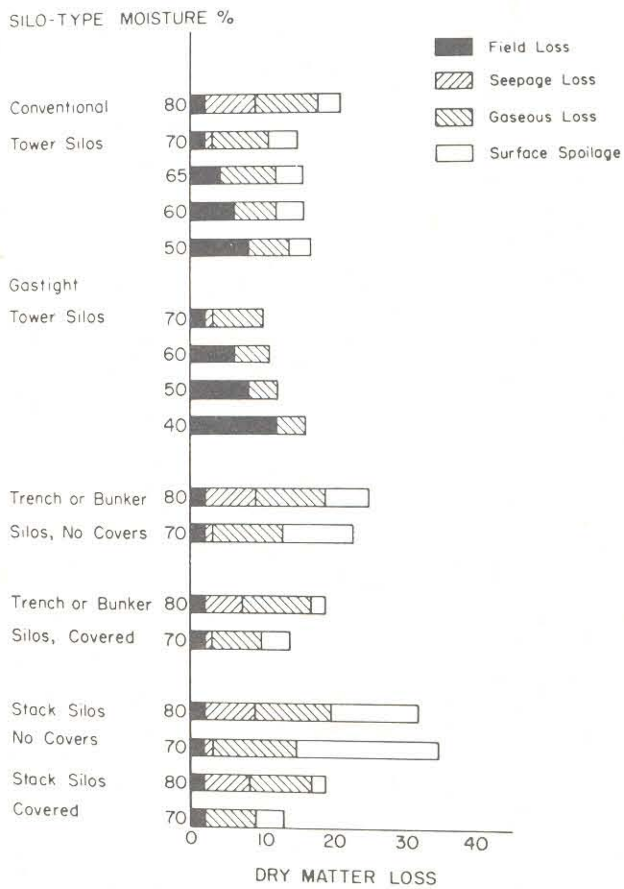

Figure 1. Estimated field, harvest and storage loss

Courtesy: Heath, M.E., D.S. Metcalfe and R.E. Barnes, *Forages,* 3rd ed., Iowa State University Press, Ames, Iowa. 1973.

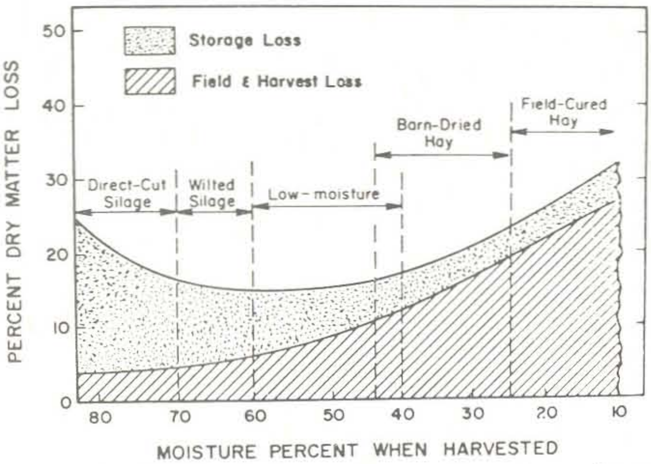

Figure 2. Field and storage loss with various silage systems

Courtesy: Heath, M.E., D.S. Metcalfe and R.E. Barnes, *Forages,* 3rd ed., Iowa State University Press, Ames, Iowa. 1973.

not necessarily mean there is no great loss in feeding value. For example, heating of the silage causes a reduction in protein digestibility through a process known as "browning" or the Maillard reaction.

Silage fermentation, involving the production of lactic acid plus lesser amounts of other compounds, produces very little heat. For silage to heat air must be present in the silage mass. Heating in silage during the first few days following harvest is caused by: (1) plant respiration; and (2) yeast and mold activity. Later in the storage period, heating is related to yeast and mold activity only. Minimizing air exposure is the key to the production of good quality silage.

Heating results in a "toasting" effect on the silage which darkens the color. The darkening color, or browning, is caused by the combination of part of the silage carbohydrate with part of the silage protein to form a brown undigestible compound similar to lignin. Thus, protein tied up by the browning reaction is relatively unavailable to livestock.

Laboratory experiments indicate that high temperature storage reduces the protein digestibility of silage (Table 1). The browning reaction also increases with the length of the heating period. Since silage is stored for relatively long periods under farm conditions, the browning reaction would proceed towards its maximum for the particular temperature level attained. The reaction appears to start at approximately 40°C (100°F).

Table 1. Protein digestibility (%) as affected by temperature and length of storage

Heating period (days)	43°C (110°F)	57°C (135°F)	71°C (160°F)
0 (control)	69.7	69.7	69.7
3	68.7	65.8	60.2
9	68.4	64.4	50.0
18	65.2	58.6	35.8
30	65.4	49.0	30.1

Data from: D.W. Gallagher. Heat Damage in Hay-crop Silage. M.Sc. Thesis, 1976. University of Guelph.

Heat damage is measured in laboratory analysis using the acid detergent fiber — nitrogen (ADF-N) test. When the nitrogen content measured using ADF-N is above 0.29% on a dry matter basis, the sample may be considered heat damaged. The protein digestibility of these samples is 60% or less, whereas excellent quality silages should have protein digestibilities in excess of 65%.

Farmers have recently tended to store silage at lower moisture contents than in the past. Following are some of the reasons for suspecting that lower moisture silages are more susceptible to heat damage than higher moisture silages if excessive air exposure is permitted:

1. The fermentation process in silage results in a decrease in silage pH and utilizes water soluble carbohydrates in the reactions. Thus the more complete the fermentation, the fewer soluble carbohydrates there are remaining to participate in the browning reaction. Since the amount of fermentation decreases with decreasing moisture content of the silage, it would appear that silages may increase in susceptibility to "browning" as moisture content decreases. It has also been suggested that the extent of the browning reaction increases with higher pH (higher pH occurs when silage is drier and ferments less) although the rate of the reaction may be slower.
2. Drier silages do not consolidate as well as wetter silages. Therefore drier silages have decreased resistance to air infiltration and the probability of heating is increased.
3. The specific heat* of silage decreases as the moisture content decreases. Therefore a given amount of heat produced will increase the temperature of a drier silage more than a wetter one, and more damage will occur.

Management Practices

There are a number of management practices that are important in the production of high quality hay crop silage. Producers aiming for a 20% protein package should give serious consideration to the following:

1. *Proper attention to forage species selection* Pure legume stands will produce far more protein than legume-grass or pure grass stands. Percent protein in the grasses is only about half of that found in the legumes. Sowing a grass with a legume will dilute the protein percentage of the stand and greatly reduce the quality of the harvested product. Alfalfa produces more protein per hectare than any other crop grown, including soybeans. It is by far the highest yielding of the perennial forage legumes and should be the species of choice wherever it can be grown.
2. *Harvest at the proper stage of maturity* Legumes such as alfalfa, trefoil, and clover should be harvested in the early bloom stage; grasses in the early

**Specific heat — the amount of heat required to raise 1 gram of material 1°C.*

stage of heading. Forages harvested in the early stages of growth are higher in protein and energy value and are more palatable. With grass-legume mixtures harvesting should be done to correspond with the proper stage of maturity of the legume, since this is where most of the quality is found.

3. *Use the proper length of cut* Fine chopping helps to exclude air because packing is tighter. A 1/4 to 3/8-inch cut is desirable with 65% moisture silage and absolutely necessary with haylage containing less than 60% moisture. The correct chop is necessary for both conventional and sealed tower silos. Air will penetrate the haylage mass in sealed towers when the filling port is left open or when the unloading door is opened for feeding. Length of cut and its influence on packing is probably most critical for horizontal silos. Harvester blades must be sharp and set correctly. Ledgerbars must not be worn badly. Chopping finer than a quarter inch is not necessary and undesirable since it is often a contributing factor to depressed butterfat test.
4. *Maintain the proper moisture content* Alfalfa will retain 70% moisture (30% DM) without seepage at normal silo pressures. To allow for a safe operating range, start filling when the forage has wilted to about 70% moisture. Later loads will be drier. Haylage usually contains 45 to 65% moisture. However, by waiting until 55% moisture before filling, much of the forage will be too dry to insure good packing and the risk of heat damage will be great. If the material becomes too dry, cut fresh forage and continue to fill the silo by alternating dry and wet loads. Moisture contents generally need to be higher for horizontal silos in order to get good compaction.
5. *Provide a tight silo* The walls and doors of new silos are usually air-tight. However, older silos may have air leaks in the walls or around the doors. These should be reconditioned and/or caulked and sealed. The silo acts like a chimney. If air can get in near the bottom it will be funnelled right up through the silage mass. This could in turn lead to excessive heating and spoilage.
6. *Distribute evenly in the silo* Even distribution in the silo is necessary to avoid separation of the light from heavier material by the silage blower. Light material tends to land next to the wall, which leads to poor packing and easy air penetration. If the wall happens to leak air, or when the feeding door is opened in bottom-unloading silos, a chimney effect is produced.
7. *Fill the silo rapidly — continuously if possible* Compaction of the forage depends on considerable height of material to provide the weight necessary to express air from the mass. Therefore, the upper portion will tend to be less dense and hold more air which causes heating. If filling is delayed over several days, the upper layer for each filling will be noticeably different in quality. Sealing the silo during down time will help to reduce this effect.
8. *Seal the silo* Sufficient moisture is necessary to supply weight for compaction. Forage in the upper one-third of the silo should contain 65 to 70% moisture in order to get a better pack. In air-tight silos the door should be closed as soon as silo filling is complete. In conventional tower silos the forage should be levelled and sealed with plastic if the silage is not to be fed out immediately. Sealing with plastic is essential on horizontal silos. The plastic should be adequately secured and weighted down. If allowed to flop, the plastic cover can act like a bellows by forcing air into the silage mass.
9. *Analyze for heat damage* Dairymen having a feed analysis done should request the acid detergent fiber-nitrogen (ADF-N) test to determine protein digestibility. Color and odor of the silage are not good indicators of protein digestibility unless the silage is extremely dark and/or has a burnt odor. Any indication of browning of the silage or burnt odors should be checked by a digestibility test.

Feeding Guidelines

1. Collect a composite sample of silage for feed analysis as the silo is being filled. Take a handful from every third or fourth wagonload and place in a green garbage bag. Mix the contents at the end of the day and freeze a subsample sealed in a freezer bag. After the silo is full, the samples should be thawed, mixed and a subsample submitted for feed analysis. If a digestible protein analysis is desired, then a sample should be collected after the ensiling process has been completed and the silo has been open and fed from for at least two weeks.
2. Balance a feeding program for dairy cattle or beef cattle around the feed analysis results. Either the Dairy Ration Formulation Service or the Beef Finishing Program can be of assistance in developing a balanced ration which makes optimum use of the protein contained in the hay silage. Note that hay silage is a good source of crude protein and calcium when compared to corn silage.

Average Analysis (Dry matter basis)*

	Number of Samples	Dry Matter %	Crude Protein %	Calcium %	Phosphorus %	TDN %
Legume hay crop silage	42	48.62	18.51	1.48	.27	59
Corn silage	1181	34.46	8.63	.24	.24	67

**Actual Analysis of field samples submitted to University of Guelph Feed Lab during 1977/78*

3. Keep hay silage away from dry dairy cows where high intakes of calcium have been found to result in increased incidence of milk fever. For details see OMAF Factsheet *Feeding and Managing Dry Cows*, Order No. 79-029.