CORN STOVER AND SILAGE

CORN STOVER

When corn is harvested for grain, 40-50% of the dry matter of the corn plant remains in the field in the leaves, stalks, husks and cobs. This material can supply feed for wintering beef cattle, wintering stocker cattle to be fattened on grass the next summer, growing dairy cattle, or dry dairy cows. Corn stover usually has a higher feed value than straw from small grains. Stover can be used by grazing or by harvesting and conserving dry in stocks or large round bales or ensiling. To estimate the tons per acre of dry matter material remaining to be grazed or baled, multiply the grain corn yield in bushels per acre by the bushel weight of the corn (56 lbs/bu). For example, a 120 bu/ac corn crop will produce approximately 3.3 T/ac of roughage. If the harvest season goes exceptionally well, and you actually achieve 140 bu/ac, the above calculation will tend to over estimate stover residues. Therefore, a cap of 4 T/ac is generally used for fields yielding 140 bu/ac.

To determine the stocking rate of your corn stover field, it is important to match the nutrient requirements of your livestock with the nutrients available. It is recommended that you test your feed to measure the nutritive value of the stover (for example, TDN, ADF, NDF, and CP), and obtain a livestock nutritive requirement table from Manitoba Agriculture, Food and Rural Initiatives.

SILAGE

Corn is a suitable crop for the production of silage. Silage is feed that has been preserved by acidification—the result of fermentation in the absence of oxygen (anaerobic). Any green crop with adequate water-soluble carbohydrates (sugars) and the correct moisture content can be cut, chopped and ensiled. Preservation of corn silage with minimum losses depends on a good fermentation. Fermentation is a process carried out by various bacteria—both desirable and undesirable—normally present on the corn plant when it is harvested. It is necessary to create a situation in the storage system so that the desirable bacteria can grow and the undesirable ones cannot.

Although some biological and chemical factors are largely outside the producer's control, there are factors the producer can manage to optimize silage quality.

Particle Size

Chopping, cutting and bruising all improve the potential for making good silage because these processes improve packing and encourage bacterial growth. A theoretical length of cut (TLC) of $^1/_4$ to $^1/_2$ inch is recommended.

Moisture

Moisture content of the crop at harvest is likely the most important factor in determining silage quality. If the moisture is too high, the crop will not ensile properly. Wet conditions promote spoilage from heating and nutrient loss (primarily soluble nitrogen and carbohydrates) through seepage and run-off. Wet silage may also freeze during the winter, creating handling difficulties. If the moisture content is too low, the silage will not pack well, thereby holding a larger amount of air for aerobic fermentation. Aerobic fermentation will promote the development of moulds and result in excess spoilage. Aerobic conditions can also produce harder and less digestible kernels.

Water-Soluble Carbohydrate Content

The fermentation process is fuelled by water-soluble carbohydrates or sugars. In general, the higher the level of sugars, the better the fermentation. All plants contain sugars, some more than others. Sugar content also varies with the stage of harvest, often measured by comparing the ration of liquid portion of the endosperm to the solid portion, also known as milkline. As a crop matures, starch and dry matter increases; however sugar levels decrease.

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Nitrates

Enzymes in plant tissue convert nitrates collected from the soil to proteins. During unfavourable growing conditions, these nitrates are not converted as quickly and therefore can accumulate in the plant tissues. Higher levels of nitrates can be a problem in some corn silage piles, resulting in reduced weight gain, and in some cases death. Since plant nitrate levels are regulated by plant growth, factors reducing plant growth may increase nitrate levels.

These conditions include:

1. Drought conditions — long sustained droughts are less likely to cause problems compared to brief intense droughts. Therefore, caution is important after drought-ending rains.
2. Cloudy weather — causes reduced plant growth and nitrate conversion rates.
3. Extremely high plant populations — reduce cob numbers and nitrate sinks.
4. Nutrient deficiencies — such as phosphorus and potassium increase nitrate concentrations.
5. Plant age and plant part — nitrates accumulate in the lower, older parts of the plant (4-6”). The stem and roots have higher concentrations than leaves and ears.
6. Fields with excess N availability — promote N uptake and increased concentrations of nitrates.

It is important to note that in some cases, ensiling can reduce nitrate levels 25-65% compared to greenfeed or green-chopping corn.

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Buffering Capacity

The pH level must be lowered as quickly as possible during the ensiling process to ensure good preservation. Plants with lower sugar contents, such as legumes, are “well-buffered” and resist this change in pH more vigorously than those with higher sugar contents (Table 10). The quicker the pH is reduced, the better, as valuable nutrients are burned up during the extended process of lowering the pH in resistant plants. Corn has a higher sugar content and thus a low buffering capacity.

TABLE 10. Forage buffering capacity

Corn	200
Ryegrass	250-400
Alfalfa	400-600
Clover	500-600

THE ENSILING PROCESS

Two types of fermentation occur in silage, depending on the amount of oxygen present in the silage: aerobic and anaerobic.

The respiration by plant cells during the aerobic fermentation or the bacterial fermentation during the anaerobic phase always results in some 'unavoidable' or 'invisible' losses in nutrients even in well preserved corn silage. With proper packing and scaling, the fermentation losses should not be more than 5-7% of the dry matter ensiled.

Aerobic Phase

In the period immediately after the silo or bunker is filled, oxygen trapped in the harvested material is used up by respiring plant cells and growing aerobic microorganisms. Moulds and yeasts are usually present during this stage and may grow if conditions are right. Proteolytic enzymes present on the plant tissue are also active at this stage and break down plant proteins into non-protein nitrogen (NPN) compounds such as amino acids and ammonia, which are not available for animal gain. The aerobic microorganisms use sugar and oxygen to produce acetic acid, butyric acid and alcohols. Other by-products resulting from respiration of plant material and microbial fermentation are heat, carbon dioxide (CO_2) and water.

The increase in temperature in the silo or bunker depends upon how much air (most importantly oxygen) is trapped in the ensiled material or how much air is allowed to enter the material after it is in storage. Lower moisture contents and less compaction will increase ensiling temperatures. Silage may be classified as warm (above 50^{o}C), medium (25%^{o}C), or cold (below 25^{o}C). The medium temperature range is most desirable and is produced from corn cut at the correct moisture content and adequately compacted. It results in a short period of aerobic fermentation, low seepage, and a rapid increase in acidity. Temperatures above 50^{o}C are produced in material that is ensiled too dry to allow adequate compaction. In this type of silage, losses of nutrients are high due to oxidation, breakdown of plant proteins, caramelization and growth of yeasts and moulds.

Cold silage is produced when silos or bunkers are filled with wet material that compacts tightly, excluding air for aerobic fermentation. In this case, aerobic fermentation may only last 5-10 hours.

Anaerobic Fermentation

When sufficient oxygen has been removed from the mass of ensiled material and the acidity has increased, anaerobic microorganisms, which grow without oxygen, such as *Lactobacilli* and *Streptococci*, take over as they are more tolerant of acid conditions. Under good ensiling conditions, fermentation will be primarily anaerobic after 3 days. Lactic acid production from these microorganisms will continue to reach its peak until the pH becomes constant at about 4.0 (Figure 22). No further change will occur in the silage if the pH remains in the range of 4.0-4.5 and no further air is permitted to enter the silage mass. If the pH fails to drop below 4.5 or air is permitted to enter the silage, bacteria (primarily clostridia) will convert the soluble carbohydrates and lactic acid to butyric acid, which results in the objectionable odour characteristic of spoiled silage. During this type of undesirable fermentation, valuable plant proteins are broken down to produce ammonia, amines, amino acids, fatty acids, and other chemicals, thus causing further nutrient loss from ensiled corn.

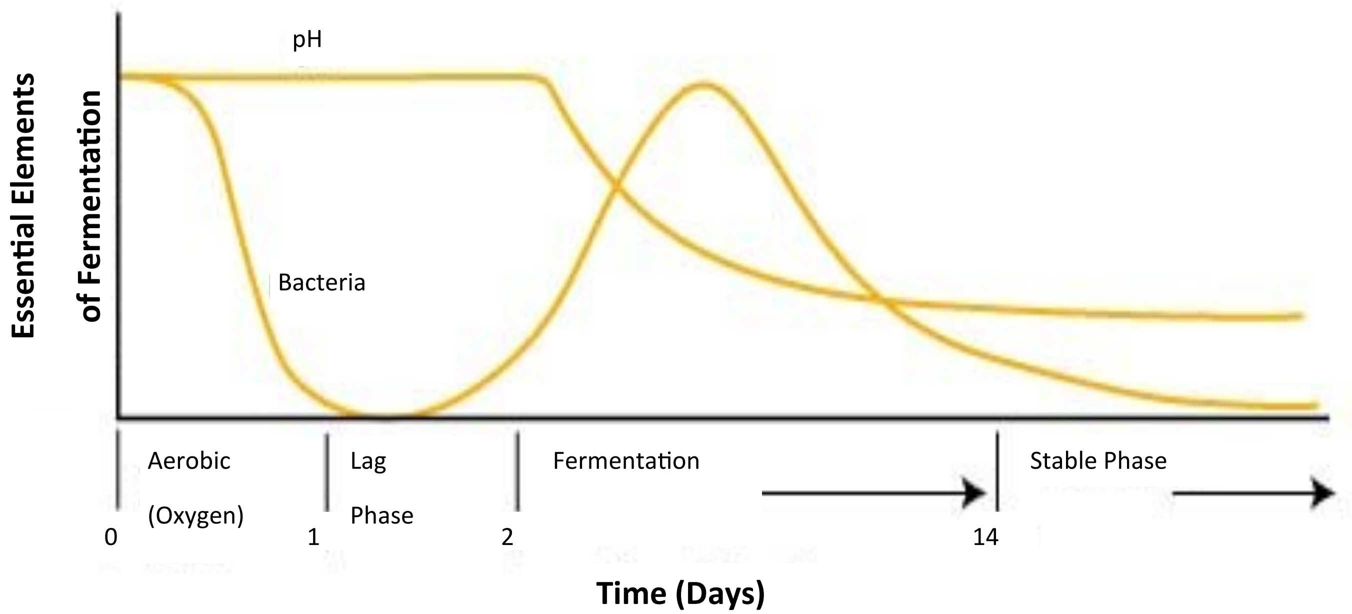

Figure 66. The changes of the essential elements of fermentation over time.

HARVESTING

Corn should be harvested for silage when:

a) The moisture content of the harvested material will ensure minimum yield losses, good fermentation and low storage losses from seepage or spoilage;

b) The yield of digestible energy per unit will be highest; and

c) The silage provided will be readily eaten by animals.

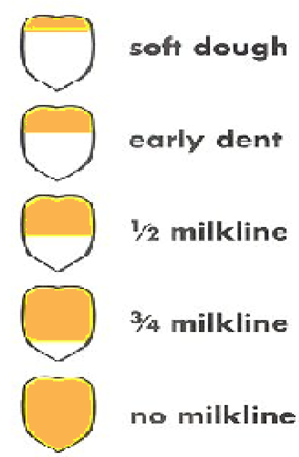

FIGURE 67. Milkline levels

Measuring Moisture Content

The harvesting stage occurs in most growing situations when the whole corn plant contains 30-35% dry matter, or 65-70% moisture. The most accurate method of determining when to harvest is to determine the dry matter (DM) on samples of the whole corn plant. If this is not possible, the producer must be able to recognize the development stage in the corn plant to make a decision on when to harvest. 30-35% moisture is approximately the time when the kernels appear glazed and well-dented and the milkline is 1/4 to 1/2 the way down the kernel (Figure 67). Table 11illustrates the moisture contents associated with milkline and the resulting quality of silage.

TABLE 11. Effect of harvest stage on yield and quality of corn silage

Maturity Stage	Moisture (%)	DM yield (t/ac)	Crude Protein (%)	NDF (%)[1]	Digestibility (%)
Early dent	73	5.6	9.9	48	79
1/2 milkline	66	6.3	9.2	45.1	80
3/4 milkline	63	6.4	8.9	47.3	79.6
no milkline	60	6.3	8.4	47.3	78.6

1 NDF = neutral detergent fiber.
Source: Wiersma and Carter, U of Wisconsin, 1993

Moisture content can also be measured with a microwave oven. To test the moisture content, weigh out exactly 100 grams of silage (adjusting for the weight of the dish). Spread the silage evenly on the plate and place in a microwave oven. Heat on high for about 4 minutes (depending on the strength and age of your oven). Remove the silage, weigh and record. Heat the sample again on high for 1 minute. Weigh and record. Repeat this procedure until the weight remains the same. At this point, the weight in grams represents the dry matter (DM) content of the silage. To calculate the moisture content, subtract the DM content from 100. Example: after several heating cycles, the sample weight stabilizes at 34 grams. Thus, the DM is 34% and the moisture is 66% (100-34).

If cutting corn that is destined for silage is past the optimum stage (i.e. moisture level), caution must be taken to minimize leaf loss, further reducing protein and vitamin A and E concentrations.

Cutting Height

Cutting height is dependent on your equipment and topography of the land the crop is being grown on. Average cutting height is typically set at 4-6 inches. Efforts of raising cutting height to increase silage quality are usually not profitable. Studies have shown that a movement from a 6 to 18 inch cutting height reduced yield by 0.6 t/ac while reducing the NDF by 0.5 - 1%, depending on planting date (Table 12).

TABLE 12. Effect of cutting height on yield and forage quality of corn harvested at 75% silk

Planting Date	Cutting Height (inches)	Yield (t/ac DM)	NDF (%)	ADF (%)	CP (%)
Early	6	10.3	59.9	34.3	12.2
	12	10	59.6	33.9	12.4
	18	9.7	59.4	33.6	12.6
Medium	6	7.6	52.4	36.5	14.8
	12	7.3	51.9	36.2	15.1
	18	7	51.4	36	15.6
Late	6	5.6	55.7	33	14.1
	12	5.3	55.3	32.5	14.4
	18	5.1	54.6	31.8	14.8

Abbreviations: DM = dry matter, NDF = neural detergent fiber, ADF = acid detergent fiber, CP = crude protein.
Source: Ballweg, U of WI, 1984.

Frosted Corn

Best results with corn silage will be obtained if the material to be harvested reaches the ideal moisture content by maturing before frost occurs. Early planting and early varieties help to ensure reaching the desired maturity while weather conditions are most suitable for harvesting. If your corn crop, which is destined for ensiling is damaged or killed by frost, caution should be taken with the next step. If the corn is only slightly damaged that the leaves remain green and on the plant, dry matter accumulation will continue, and therefore no special instructions are required. It is more of a problem when the plants are killed at a stage too immature to ensile. The plants will likely contain too much moisture for immediate ensiling, and now their dry down will be slow, while dry matter losses accumulate. The best option may be to leave the crop in the field to dry down to the desired level, unless dry matter losses become too high. If the crop is ready for ensiling when damaged/killed by frost, harvest it immediately.

Drought-Stressed Corn

Occasionally corn crops in Manitoba can experience drought conditions. In some cases, drought conditions can be severe enough that growth is unlikely to resume even after a rain. In these cases, corn crops should be ensiled. Net energy content of drought-damaged corn is often 85-100% of normal, and it sometimes contains slightly more crude protein. If drought stress is moderate, corn can often have higher than average energy (in drought years) due to the high grain content and high stover digestibility. However, one must also be aware of the potential for high nitrate levels (see Nitrates section). When in doubt, have the feed tested. Drought can also affect the whole plant moisture content. Appearance may be deceiving, as stressed crops may be holding on to more moisture than you think. Consequently, measuring moisture content before ensiling is recommended.

Storage

Before deciding which storage technique to use, you should consider volume that is needed, investment costs, structure durability, and ease of loading/unloading. The key to reducing the cost of producing silage is using storage techniques available to you that minimize silage dry matter losses due to air/silage interactions. A few key techniques to reducing these interactions are:

- Harvesting at an appropriate moisture content (Table 13)
- Using higher moisture contents for horizontal silos/bunkers to improve packing
- Filling the silo/bunker quickly with appropriate packing
- Maintaining as little outer surface area as possible
- Sealing the container well
- Feeding at an appropriate rate to minimize open face spoilage
- Maintaining a firm silo face to achieve a seal effect

TABLE 13. Recommended moisture contents for corn silage stored in various types of silos

Silo Type	Moisture (%)
Upright silo	60-65
Upright "oxygen-limiting" silos	50-60
Horizontal silos	65-70
Bag silos	60-70

If your storage is damaged during the feeding period, it is best practice to repair the area as soon as possible to minimize the amount of oxygen entering the silage. If excessive spoilage has occurred, it is recommended that you test your feed for toxins before feeding.

Pile Size

When ensiling crop in a pile, it is recommended to size the feed-out face to allow for a daily removal of at least 5” from the exposed surface. To calculated the necessary face width (in feet) for this removal rate, multiply the total amount to be fed daily by 12. Then divide the result by the product of multiplying the height of the pile (in feet) times 14.8 (silage density) times 5. Dry matter losses may be 10 percentage points less when silage is fed faster than 5’ per day.

Face width needed =

$$\frac{\text{(weight of DM to be fed in lbs x 12)}}{\text{(height of pile in feet x 14.8 x 5)}}$$

Packing Rate

An adequate packing rate in tons per hour can be calculated by dividing the tonnage of the tractor used to pack by 800. A tractor that weighs 26,000 lbs can then effectively pack 32.5 tons of silage per hour (26,000/800). In a 12-hour work-day, this tractor will be able to pack 384 tons of silage while maintaining a reasonable filling speed.

$$\text{Packing rate t/hr} = \frac{\text{(tractor weight in tons)}}{800}$$

PROS AND CONS OF CORN SILAGE

Advantages

- Silage can be harvested in almost any weather conditions
- Higher output of nutrients per acre than grain
- Can salvage crops damaged by hail, frost and high weed competition
- Large quantities of uniform quality feed can be stored
- Handling is mechanized from the field to feed trough

Disadvantages

- Requires more labour and time than hay
- Has an odour that may be offensive if stored near populated areas
- Capital investment required for storage facilities, forage harvester
- Has limited market potential. Long distance transportation is inefficient because silage is heavy and deteriorates with exposure to air.

FEED QUALITY

The protein and digestible energy content of whole plant corn silage varies with the stage at which the corn is harvested. Protein content decreases while energy content of the dry matter and the silage increases as the corn matures. Corn grown with high levels of nitrogen fertilizer will usually have a higher content of protein, perhaps by 1-2 percentage points. However, it is usually more profitable and economical to feed a protein supplement with the silage than to apply more nitrogen fertilizer. Corn harvested from a field with a very high plant population will usually have a higher protein content and a lower energy content than corn from a field with lower plant population. This is a result of delayed maturity and less ear development.

Since the energy contained in corn silage increases as the plant matures, the more mature silage has a greater feeding value (see Table 12, pg. 73). This assumes that the silage is properly fermented. The values in Table 14 for feedstuffs show that corn silage is a better energy source than the other common feedstuffs except for the cereal grains.

The contents of calcium and phosphorus in corn silage are only modest and will require supplementation for most livestock diets. In some areas, sulphur may be low in corn silage and supplementation may be needed, particularly if non-protein nitrogen sources are being used in the silage.

TABLE 14. Composition and estimated digestible energy (DE) content of corn silage and certain common feedstuffs grown in Manitoba.

Feedstuff	Dry Matter Content (%)	Crude Protein (%)	Acid Detergent Fiber (%)	Estimated Total Digestible Nutrients (%)
Corn Silage	30	9.4	31.3	68.2
Barley Silage	37	10	34.5	63.2
Alfalfa Hay	89	16.9	37.5	58.2
Barley (grain)	88	12.1	-	82.3
Oats (grain)	89	11.3	-	79.1
Spring Wheat (grain)	88	15.6	-	3.72

Planning a Feeding Program to Use Silage

The amount of silage that can be used in a diet for a particular type of animal is determined by the amount of nutrients required by the animal, the nutrient content of the silage, and the amount of silage that will be consumed. The following steps should be used to plan a feeding program that will help ensure that the desired results are obtained:

a) Obtain analyses of silage for dry matter (DM), crude protein (CP), and fibre content (ADF, NDF);

b) Determine energy value of silage (TDN);

c) Decide on performance expected of animals (rate of gain or milk production);

d) Determine daily nutrients needed to get this performance by using published tables of nutrient requirements available from Manitoba Agriculture, Food and Rural Initiatives;

e) Calculate amount of silage needed to meet the needs of the animals for energy and protein. If the amount of silage is greater than what is likely to be eaten considering the size of the animal and the moisture content of the silage, replace part of the silage with feedstuffs that have higher contents of energy or protein, or both; and

f) Feed sufficient supplements to provide adequate supplies of minerals and vitamins to balance the diet. Vitamins A, D, and E may be injected if it is more convenient than feeding in supplements.

NOTES