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SILAGE AND SILOS.

BY W. P. WHEELEER.

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GENERAL SUMMARY.

The silo affords a most economical means of assuring succulent food in winter and efficient and palatable food to supplement or supplant the dry pastures of summer.

Maize, or Indian corn, is probably the most valuable plant for ensiling.

As a succulent food for milch cows corn silage is cheaper and generally more efficient than roots.

Corn silage has proved equal in feeding value to the best dried corn fodder.

The largest growing variety of corn that is reasonably sure to ripen before frost is the best one to grow for silage.

Corn should be put in the silo after the grain is glazed, before there is much drying of the leaves or stalk. Clover should be cut when in bloom.

The essential points in building a silo are:

To have the walls tight enough to exclude air from the contents.

To have the walls not only strong, but rigid.

To have sufficient depth,—thirty feet or more if possible.

There should be not more than about five square feet of feeding surface in the silo for each cow.

The larger the silo the cheaper the storage for each ton of silage. The larger the herd the more cheaply can silage be supplied to each animal.
INTRODUCTION.

The importance of the silo, especially for the dairymen, is becoming every year more generally appreciated. The many inquiries received at this station indicate a growing interest in this method of preserving fodder. In response to many of these inquiries, especially those called out by the publication of bulletin No. 97, the following observations on silage and silos are published.

A number of fodders can be successfully preserved in the silo, but Indian corn has been so generally the crop depended upon that when silage is mentioned without qualification corn silage is commonly understood. Maize, our greatest arable crop, when at its highest value for feeding seems especially suited for preservation in this manner. The decided palatability of the fresh fodder is not diminished and as large a proportion of the digestible matter is preserved as by other methods. To fail to take advantage of the great possibilities of this magnificent crop, scarcely equalled by any other, for furnishing succulent food in winter and during time of dry pasture in summer, would appear at least very unprofitable conservatism.

At its best stage for feeding, when just mature, it is available as fresh fodder for only a few weeks in the fall. In storing and keeping the crop in any manner it is subject to some loss. The average determined loss of dry matter in the crop, when cut and shocked in the field until dry and stored in the barn, has been about equal to the average loss reported from the silo. The dry fodders, however, from which losses were estimated were, it appears, handled with more care and generally under much more favorable conditions of weather and shelter than those under which the corn crop can generally be handled, while the silos in which losses were estimated were not all of them suited to produce the best possible results. It is probable that experience will enable us to considerably reduce the amount of loss in the silo, but it is not so likely that the necessary loss in keeping the dried fodder can be materially diminished. The cost of good barn shelter for hay or dried fodder containing an equal amount of
nutriment to the silage is as great as that of the silo. The same amount of dry matter in food can be stored in the form of silage that would occupy about three times the space in the form of dried fodder.

When fed in quite large quantities corn silage is usually eaten without waste, but when feeding the dried fodder there is as a rule considerable refused by the cattle, especially if the fodder is not finely cut or shredded. For feeding in summer to cows that have some pasturage, the dry fodder will not do, for not enough will be eaten to sustain the milk flow, while silage is readily eaten and in time of dry pastures during the latter part of summer will help greatly to keep up the flow of milk.

The loss of protein in corn kept in the form of silage is proportionally somewhat greater than that in the dry fodder. Even without this loss, and also when feeding the fresh plant, corn requires an accompaniment in the ration for milch cows of some more nitrogenous food. Usually such highly nitrogenous grain foods as linseed meal, cottonseed meal and the gluten meals are fed to good purpose with corn silage. The possibility of feeding liberal quantities of these products when their market prices are lower than their fertilizing values may be considerable advantage on farms where commercial fertilizers are regularly purchased. Wherever it is desirable for any reason to feed but little grain it is well to have clover hay for winter feeding and clover or some mixed pea silage with that of corn for summer feeding. When several silos are used, or a large partitioned silo, the different kinds of silage stored separately can be fed together.

Clover makes silage of excellent quality and has been used for this purpose in many silos through the country. Several mixed crops have been tried at various times but not extensively. A favorable result from the trial of silage made from equal parts of green corn fodder and green soja bean fodder was reported from the Massachusetts Experiment Station, summarized as follows: "Corn and soja bean silage has proved itself fully equal if not superior to hay in producing a yield of milk, without affecting the quality, and at the same time decreasing the absolute cost." At the Vermont Experiment Station the results of a short feeding trial were thought to promise as good returns from oat-and-vetch and oat-and-pea silage as from corn silage.
Silage and Roots.

The advantage of having some of the food for milch cows during winter in a succulent form is very generally appreciated, and the results derived from the addition of roots to the ration have often been out of proportion to the actual amount of food constituents supplied by them. For feeding cows for a while before calving, roots are better than silage, and silage could not economically supplant roots where too few animals are kept to warrant the expense of building a silo, or to empty a silo fast enough to prevent the loss from decay at the surface. Where many cows are kept, however, corn silage is a much cheaper food for milk production than roots. Some of the results obtained at this station from rations containing roots compared with those from rations containing silage have been noticed in bulletin No. 97.

At the Ohio Experiment Station the same amount of dry matter of the food was found to produce on the average about six per cent. more milk from corn silage than beets. At the average yield, the cost of dry matter in beets was more than double that of the corn.

In a feeding trial at the Pennsylvania Experiment Station more butter was produced when cows were fed silage than when fed beets. The cost of growing an acre of beets was found to be about twice as much as an acre of corn, and about twice as much dry matter was obtained from an acre of corn as from the same area of mangels or sugar beets.

In some feeding experiments with lambs at the Michigan Experiment Station, rations containing silage were found more profitable than others containing beets.

Losses in the Silo.

Even with an unusually large loss from keeping corn in the silo the silage would be a cheaper food than roots. The loss however in the silo is not greater than with the dried fodder. The average loss in many instances where observations were made was for dry fodder and silage, about 20 per cent. of the dry matter in the fresh crop. The loss in the silo, aside from that by decay at the surface and exposed corners, was found on the average of several determinations made at this station to be about 12.6 per cent. There was a loss of about 18.5 per cent. of the albuminoids and 26.6 per cent. of the sugar and starch.
At the Wisconsin Experiment Station under favorable conditions a loss of dry matter of the crop of not much more than 8 per cent. was found including all loss. It was estimated that the necessary loss could be made much smaller.

**Ensilage and Field Curing.**

Experiments made at the Pennsylvania Station on the influence of ensiling and field curing on the digestibility of forage corn led to the following conclusion. "When the processes are successfully conducted and the losses small, ensilage and field curing both decrease the digestibility of the fresh material somewhat, and to about the same extent."

While it has been estimated by some who have investigated the subject that dried fodder and silage when properly prepared have very nearly equal value for milk and butter production, a majority of feeding trials have shown advantages in favor of corn silage, and it is generally concluded that the silo furnishes the most economical means of feeding the corn crop entire.

In some feeding trials with steers at the Utah Station the animals having dry fodder gained in weight while those having silage lost in weight. The conclusion was that for such a climate where easy curing of fodder could be expected the silo was undesirable.

The results of a number of experiments with silage at the Kansas station were summarized as follows: "If we estimate that 77.2 per cent. of the amount put in can be taken out sound and available for feeding, or about 1,544 lbs. for every ton put in the silo, we find that, at the average feed of 32 pounds per day, one ton will last one animal 48.2 days, or 100 tons will last a herd of 25 head 192 days; and in a reasonably favorable season, with good soil and good culture, this 100 tons may be grown on about 10 acres. What other method of handling corn fodder will maintain an average farm herd during the long winter season from grass until grass comes again, on so small an area?"

**Maturity and Variety.**

Corn when just mature, at the time it would be cut for husking, when the grain is glazed and just before much drying of the
leaves occurs is at its best for ensiling. In a deep silo corn can be put in when glazed and nearly ripe when the best quality of silage can be made, but in shallow silos the more mature corn will not pack sufficiently to exclude air and greener and heavier corn has to be used making poorer silage.

A variety of corn that is reasonably sure to mature before frost is best to grow for silage even with the expectation of a lighter acreage yield than could be obtained from some of the large, late maturing varieties.

The report of some investigations made at the Pennsylvania Experiment Station was that "As the corn crop approaches maturity there is a very rapid increase in the yield of dry matter per acre, while the digestibility of this dry matter appears to increase slightly, rather than to decrease as in the case of other crops. The yield of total digestible food by the fully mature crop was from two to three times as great as that by the same variety in the silking stage, and 36 per cent. greater than at the time the ears were glazing."

At the Minnesota Station in a trial of varieties of corn for silage it was found that "a hundred pounds of dry matter in either dent, sweet or southern ensilage corn proved very nearly of equal value for producing milk and butter in these trials, though the advantage in all cases was slightly in favor of the silage from the dent corn."

In experiments made at the Maine Station it was found that the smaller varieties of native corn which ripened in Maine were more digestible than southern field corn; 65 per cent. of the dry matter in southern corn being digestible and 73 per cent. of the dry matter in the Maine field corn. "Pound for pound the Maine field corn silage was worth more than southern corn silage." Experiments at that station for five years showed that the average yield per acre of southern corn was 17 tons and of Maine field corn something over 11 tons. The average dry matter per 100 lbs. was nearly one-third more in the Maine field corn. The results of comparison were summarized by Prof. Jordan in part as follows: "The yield of digestible dry matter has averaged 175 lbs. more with the southern corn. To offset this it has been necessary to handle annually five and three-fourths tons more in weight."
SILAGE FOR DIFFERENT STOCK.

While silage has been used almost entirely for cows it can be fed with good results to some other animals, but it should not be expected that any should subsist wholly upon silage. For feeding steers corn silage has been successfully used in many trials, and rations containing silage have quite often given more profit than other rations fed in comparison. While corn silage was found at the Kansas Experiment Station most satisfactory for cattle generally, it was considered an unsuitable food for breeding bulls.

Many reports favor the use of silage for sheep, and a number of feeding experiments indicate its profitable use. It is recommended by several experienced men with the caution to feed but little of that containing much grain to breeding ewes.

Silage has been fed to horses without trouble; but it should not be fed in large quantities, especially in cold weather, and silage containing much acid should not be fed at all. Some experienced feeders have successfully used it for horses and mules; others after unsatisfactory experience, have considered it an unsafe food.

Silage is a desirable and well received addition to poultry rations in winter. Compared to the amount consumed by other stock it is a trifling total that would be eaten by an ordinary flock during the season.

Silage is eaten in moderation by pigs. In feeding trials made at this station, corn silage could not be fed to pigs profitably in quantities large enough to warrant our calling silage a suitable food for them. Only very insignificant amounts of silage could be fed with profit.

SILAGE AND MILK.

In winter for milch cows it has generally been customary with us to feed once a day some dry fodder, preferably clover hay, and silage twice with grain. A number of rations that have been fed, containing silage, were mentioned in full in Bulletin No. 97. Feeding of corn silage did not produce any inferior quality of milk so far as chemical composition would indicate and no objectionable flavor was noticed. If radical changes in the ration were made gradually and not suddenly and no spoiled or moldy silage
allowed to reach the cow, it is probable there would be little complaint of any unpleasant flavor from silage. Of course, milk should not be exposed long in a stable filled with odors of silage or any others objectionable. At the Kansas Experiment Station the occasional taint noticed in the milk when silage was fed, was entirely avoided by feeding the silage immediately after instead of before milking.

**Silo Construction.**

In building a silo the essential idea is to have a structure that will effectually exclude air from the mass of fermenting fodder. The first fermentation will not then be followed by souring and decay.

The earlier silos were mostly pits in the ground, often too shallow for good results, afterward carried up above ground with stone or brick. They were inconvenient of use and the more effective ones were costly. First class silos can be made of stone or brick if the inner walls are made smooth and vertical and well plastered with the best cement. Cemented or plastered walls will need a thin coating of cement each year to prevent action of the acid and absorption of so much moisture that the walls will crumble from effect of frost.

The less costly wooden silos are now most generally used. If built inside the barn a "square" silo or other rectangular one, often with partitions, is the common form, and if built outside the barn the round or cylindrical form of silo is preferably adopted.

**Rectangular Silos.**

A "square silo" built in the corner of the cattle barn at this station eight years ago, 14 ft. x 15 ft. inside and 30 ft. deep, was constructed like many others in use at that time. The only change of any consequence made since has been that of boarding across the corners where air leaked in and most of the spoiled silage was found. This has been an improvement. The bottom of the silo is two and one-half feet lower than the basement floor. A stone wall extends around the bottom of the silo from below the frost line two and one-half feet high on the inner sides and eleven and one-half feet high on the exterior sides, these sides being formed by the main wall of the barn. Underneath the silo
are six inches of stone from which a tile drain runs. On the stones a three-inch layer made of two parts cement and three parts gravel forms the floor. The stone sides are smoothly plastered up to the wooden wall. The upright timbers are 28 feet long by 5 by 10 inches, set three feet and eight inches apart with 2x10-inch studs set between. The bottom ends of the timbers are backed by nine inches of stone and cement of the basement

**Figure 1**

Corner of rectangular silo

floor. These uprights are also held by the second floor at the top and the main floor in the middle. Above the main wall on the two outer sides 2x10-inch studs only are used. The inside is boarded horizontally with matched hemlock, and again with matched pine, tarred building paper being between the two coverings of boards. The outside is covered with good quality of hemlock flooring. In the basement there is a door near the corner of the silo through which the silage is taken when low enough. A trap is over this in the main floor of the barn and two doors in the silo above in line make convenient the removal
of silage and the filling in the fall. In this silo about 120 tons can be put and a first-class product obtained. The walls are not quite firm enough, however, and the springing caused by the pressure when filling is enough to admit some air as the mass of silage settles and cause considerable loss from decay that would not occur if the walls were more rigid.

The accompanying illustration Fig. 1 shows the common method of boarding up a rectangular wooden silo, a sheathing of paper going between the two courses of boards. The partitions at the corners can be put across after the first course of boards instead of after the vertical second lining is in place, as shown in the illustration.

There are other styles of rectangular silos having rigid framework of strong horizontal girders, sometimes formed of three 2x10-inch planks spiked together. These have certain advantages. With any form of construction, however, especial attention should be given to securing a strong and inflexible framework. This should be stronger below the middle of the silo where the greatest pressure is found. The sills should be fastened to the foundation walls by heavy bolts imbedded firmly in the walls. The joints of the frame can be strengthened and horizontal girders held firmly together at the corners by short cross braces which will serve as backing to the boarding across the corners.

LOCATION.

The silo should stand where the ground is dry and well underdrained, naturally or artificially, and protected from all exposure to water from the outside. In a favorable location the silo can with advantage run several feet below the surface of the ground. This is especially desirable as increasing the depth of indoor silos where the height of the walls above ground is restricted.

THE ROUND SILO.

The round or cylindrical wooden silo is now in quite general estimation. While about the least expensive in construction it is not surpassed in efficiency. This form of silo is recommended in preference to others by Prof. King of Wisconsin, who has given especial attention to the subject for several years and studied the results obtained with many silos. Most of the following recom-
mendations in regard to the construction of round silos are taken from the publications of the Wisconsin Experiment Station and the illustrations are reproduced from similar ones in reports of that station.

FOUNDATION AND FLOOR.

The foundation wall should extend below the reach of frost and be about 18 inches thick. The top of the wall should be beveled on the inside. The wall should be thoroughly plastered with a mixture of two parts of good cement and three of sand, plastering carefully about the sill and bottom of lining so as to exclude all air. The bottom of the silo should be grouted and cemented to exclude rats which by burrowing under admit air and cause considerable loss. Otherwise a good dry clay floor might suffice. At the Kansas Experiment Station two silo floors consisted simply of tamped clay and a third had a cement floor. The clay floors were thought to answer every purpose.

FRAMEWORK AND WALLS.

The sill is made from pieces of 2x4-inch scantling. The pieces are cut into about two feet lengths on the slant of two radii of the circle of the silo, are toe-nailed together on the wall, bedded in mortar and leveled. By some it is recommended to lay a double course of 2x4 scantling for the sill, breaking joints with the pieces. The pieces for the plate, also of 2x4 are spiked on the tops of the studding. It is unnecessary to cut the pieces to a circle. Studding long enough is made by lapping. The studding need not be larger than 2x4 inches except for silos of very large diameter. The studs are set a little nearer than 12 inches from center to center, and are toe-nailed to the sill. Every alternate stud is set first and stayed by a board to a temporary post in the center of silo. These studs are made plumb and stayed by a few strips of the outside sheeting tacked to each. The intermediate studs are then set in and nailed to the strips. The outside sheeting and siding are started at the bottom and carried up together. The lining is then put on. The lining of the round silo is made of fencing lumber split in two making a little less than half-inch lumber. The fencing should first be sized to be of unvarying width. Three layers are put on the inside with good
quality tar paper between as shown in Fig. 2. For the last layer 10 d. nails are used and 8 d’s. for the first two. The sheeting outside is of the same lumber except for very large silos. The ordinary siding for small silos is rabbeted on the thick edge. The doors are usually cut in after the lining is on except one at the bottom. These are about two feet wide by three or four feet high. The studs at each side of where the door openings are to come are made double. Different kinds of doors, boarded both sides of cleats made of scantling, are recommended to swing on hinges. It would perhaps be better to have an outer door to swing on hinges, and have a double set of short one-inch boards cut to fit, in length equal to the width of the opening, held in place by cleats nailed on the studs. The inner surface of the boards may be flush with the inner lining of the silo and a layer of tarred paper should be between the boards. Where the filling is done through the one door at the top of the silo it is made
about 3 feet wide and high enough to readily admit a man at the side of the carrier. The location of such a door is shown in Figure 4.

**Roof.**

The roof can be made in any convenient style but is usually conical or two sided as shown in the illustration. A conical roof on one of the smaller sized silos can be made without rafters, a

![Image](image.png)

**Fig. 4**

circular frame about 6 feet in diameter being sawed out of pieces of 2x8-inch plank and the roof boards nailed to this and to the plate. A cupola of some sort is considered essential to good ventilation.

**Freezing and Ventilation.**

As a protection against freezing the outer covering of the silo is necessary. In exposed locations this covering should be thick, for frozen silage cannot be safely fed in any large amount. Silage of the better quality made from the drier and riper corn seems less liable to freeze than that of poorer quality made from more immature corn. For securing ventilation behind the inner lining to prevent its rapid decay, holes are bored through the outer siding between the studs just above the sill as shown in Figure 3. These holes are covered with coarse wire cloth to keep out rats and mice. The inner lining is not carried quite to the
plate, the opening at the top being also covered with the wire cloth or screen to keep silage from falling in.

An efficient round silo could probably be constructed of staves—one, at least, successful silo of this style has been reported,—but first class sound lumber not less than two inches thick would have to be used and there would be difficulty in having suitable openings. Emptying all from the top would be decidedly inconvenient.

**Cost of Silos.**

The cost of the silo would be affected by many varying local conditions, and prices for labor and material. The estimates for rectangular silos can be readily made by different builders. Square silos built in the barn without roofs holding 100 tons have been estimated to cost less than $160. Some other estimates have placed the cost considerably higher. A round silo about 20 feet in diameter and 30 feet deep holding about 180 tons will probably cost in this state from $300 to $350. King estimated the cost of a rectangular silo holding 200 tons at about $425, and of a round silo holding the same amount at about $247. A stone one of this capacity cost about $500.

The average loss of silage that has been heretofore reported is so much greater than is necessary under favorable conditions in well constructed silos that it is poor economy to build any other than a first class silo.

**Preservation of the Silo.**

The deterioration of most silo linings was formerly very rapid from decay or crumbling, but recently it has been less noticeable since the silos have been better made and filled with riper material. Yearly plastering or covering cement linings with a light coat of cement whitewash prevents largely the injurious action of the silage juices. Metal linings have not been found satisfactory. The cheaper metals corrode rapidly, and paint has not seemed to adhere well. Ventilation of the double walls of the wooden silo and an occasional coating of preservative on the inner surface retards decay. Coal tar or gas tar is highly recommended by some authorities. This is thoroughly applied, while hot, to the inner surface.
Each year for several years past the inner surface of the wooden lining of the silo at this station has been painted with a mixture of two parts, by weight, of paraffin, two parts rosin, and one part boiled linseed oil. These substances are melted together and the mixture applied, while hot, with a brush. The proportions of these constituents have been varied somewhat without apparent change in the result. This mixture is inflammable and should be carefully handled about the fire. The wooden lining, thus treated, after several years' service has a hard surface and there is no decay noticeable. A wood surface not treated would hardly have endured for this time without some decay.

**Filling the Silo.**

When the fodder has reached proper maturity it is put into the silo directly from the field, simply being evenly distributed over the interior and well trodden about the corners and sides. It is possible to preserve most fodders including even corn by ensiling whole as the plant comes from the field, provided the silo is deep enough, but it is not a satisfactory way. It has been customary at this station to cut the corn for silage into three-fourths-inch pieces—the ears cut along with the stalks.

Corn is best for silage in the stage of maturity when it would generally be cut and shocked in the field. In a shallow silo greener corn must be used, for the drier corn will not pack closely enough to keep. If filled rapidly enough to insure against decay at the exposed surface, there is no need of haste in filling. When the silo is full the top can be covered with grass or any finely cut cheap material that may be available. If not moist or juicy the top few inches of material can be moistened thoroughly by pouring water over it. The few inches at the top should be wet and compact to prevent the surface decay extending too deeply. When nothing more convenient than corn is available for covering the ears can be picked from several loads before running through the cutter enough for the top few inches of material. When silage is fed the year around or feeding begins immediately after filling, the loss from decay at the surface is avoided and no especial effort is necessary to preserve the surface.
Harvesting.

It is customary to cut the corn in the field by hand, and this has been the practice at this station. A form of cutter devised for attachment to a low wagon to be drawn by horses was found unsatisfactory. A machine used at the Kansas Experiment Station with better satisfaction than any other of those tried is of a simple pattern similar to a cutter recommended by others. It consists of a \( \Delta \) shaped sled frame drawn by one horse. There are two knives one on each wing, set to cut, two rows at a time. The wings are hinged to fold up toward the center when not in use. The frame is mounted on four low, broad, iron wheels. Two men stand on the cutter and gather the corn in bundles as cut.

For convenience in handling the heavy material, a low wagon having wheels with broad falloes and tires 5 or 6 inches wide and having a nearly level tight rack of boards is best. By the Wisconsin station is recommended a wagon on high wheels having a level rack, narrow at the front and somewhat longer than usual hung under the axles, enabling a man to readily load from the ground. The fodder cutter is set so that the carrier delivers the material near the center of the silo.

Clover is often put into the silo whole but it is better to run it through the cutter. It is not so easy to pack clover closely as it is the heavier corn and in a shallow silo it fails often to keep well. During the process of filling it should be well trodden down at the edges and corners. Clover should be cut for silage when in bloom and if at the right stage of maturity, should not be ensiled when very wet with dew or rain. On the other hand the clover should not be too dry for there is much heat from fermentation. Sometimes clover is moistened two or three times in the silo during the process of filling. About two days after the silo is full the surface should be well trodden and saturated with water and again after several days. The matted moist layer at the surface will better exclude air and protect the silage from decay.

Silage from sorghum is made the same as that from corn but it is more acid, and inferior to corn silage.

In emptying the silo it is important to begin at the top and remove from the entire exposed surface daily, otherwise there will
be great and unnecessary loss from rapid molding and souring. It is advisable to have the capacity of the silo suited to the size of the herd so that an average of about two inches or more in depth of silage will be fed daily. The depth of silage removed daily will be greater than this near the top of the silo and less near the bottom. About five square feet of feeding surface per cow is a fair estimate. For a herd of 30 cows a cylindrical silo of about 14 feet inside diameter would be satisfactory. A herd of 50 cows would take the silage from one 18 feet in diameter. The weight per cubic foot of corn silage at the bottom of a silo 30 feet deep is about 60 pounds, towards the top it is about 30 pounds. The average weight per cubic foot of silage in a deep silo can be taken as something over 40 pounds.

Silage is not a food suited to all conditions and all times and should not be fed to the exclusion of other foods essential to a good ration, but there is no longer question as to its efficiency and the economy of its use.