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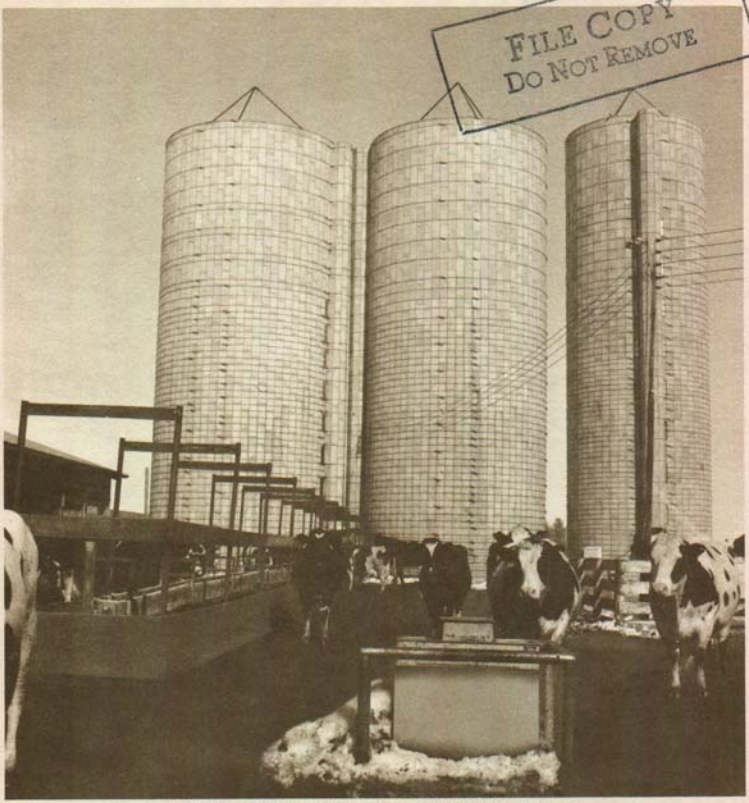

See Diagram and Description of this type of Storage and Feeding System on page 8

"CORNAGE"

high moisture corn for dairy cattle

Cooperative Extension Service — Michigan State University

"CORNAGE"

high moisture corn for dairy cattle

BY DONALD HILLMAN[1], AND
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"CORNAGE" IS GAINING FAVOR among dairymen as a means of harvesting and storing corn grain. Cornage is a coined name for high moisture corn. It is stored in concrete stave, poured concrete, or gas-tight silos as ground ear corn, ground shelled corn, or whole shelled corn at 25 to 35 percent moisture levels. High-moisture corn handled in this manner offers certain advantages over conventional corn handling methods.

1. Harvesting can be done 2 to 3 weeks earlier than for cribbing — frequently this could mean the difference between saving or losing much of the corn crop.
2. Illinois studies show 7 percent less field, harvesting, and storage losses for 25 to 30 percent moisture corn than with dry corn. Several rehandling operations are eliminated since the cornage is ready to feed when removed from storage.
3. Storage costs are comparatively low. Estimates indicate annual silo storage cost (including unloader) are 2 to 4 cents per bushel less than crib storage and up to 8 cents per bushel less than for heat-dried shelled corn.
4. Storage is relatively rodent-free.
5. Mechanical feeding in the lot is simplified.

Nutritional Value

Feeding trials with milking cows at the University of Illinois and Michigan State University indicate that properly handled cornage is fully as satisfactory as dry corn for milk production. Growth studies with heifers indicate that cornage is equivalent to dry corn but not better. Beef cattle fattening trials have shown variable results with cornage compared to dry corn. In general, there appears to be a slight, but not significant, advantage in average daily gain and feed efficiency with ear cornage compared to dry ear corn. This advantage was not apparent in numerous trials comparing shelled cornage with dry corn. Since the nutritional value appears to be about the same as for dry corn, any advantage for cornage must result from greater efficiency in handling and storing.

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Harvesting

Corn kernels continue to accumulate dry matter until they drop to 35 percent moisture, although a few hybrids will mature at 40 percent moisture. Corn is considered to be mature after it has accumulated all of the dry matter possible. Fifty percent moisture corn is dented and in medium soft stage but is not mature. Twelve to 16 days are required to mature corn from 50 percent to 40 percent. The yield increases at a rate of ½ to ¾ bushel per acre per day during this time.

Table 1 — Capacity of Harvesting Equipment*

Machine	Row width	Picking speed	Field efficiency	Acre per hour	Bu/Hr. @ 100 Bu/Acre
1-Row Picker	40 in.	2.5 mph	65.0%	0.65	65
2-Row Picker	40 in.	2.5 mph	60.0%	1.20	120
2-Row Picker-Sheller	40 in.	2.5 mph	62.5%	1.25	125
2-Row Combine	40 in.	2.5 mph	65.0%	1.30	130
4-Row Combine	40 in.	2.5 mph	60.0%	2.40	240

* Since most devices for grinding high moisture corn will usually handle approximately the capacity of a two-row harvester, this table can be used as a guide for rate of grinding.

Table 2 — Kernel-Cob-Ear-Moisture Ratio*

Kernel Percent Moisture	Cob Percent Moisture	Whole ear Percent Moisture
12	12	12
14	15	14
15.5	18.6	16
18	27	20
20	33	23
22	38	25
24	44	28
26	47	31
28	50	33
30	52	35
32	54	37
34	56	39
36	57	41
38	58	43

* Iowa data; this and other information on corn maturity provided by Elmer Rostman, Farm Crops Department, Michigan State University. From: *Michigan Cattle Feeder*, Vol. 1:1, November, 1960. Animal Husbandry Department, Michigan State University.

The most desirable moisture range for the total handling system is 26 to 28 percent kernel moisture. At this moisture range, good machine performance results and field losses are at a minimum. Horse power requirement increases at higher moisture. Whole kernel corn flows poorly at kernel moistures above 25 percent.

Recommended Storage Moistures

Shelled cornage — ideal kernel moisture is 26 to 28 percent, the recommended range is from 25 percent to 30 percent, and the limits are from 25 percent to 33 percent.

Ground ear cornage — ideal kernel and ear moisture is 32 percent, recommended range is from 28 to 35 percent, and the limits are from 25 percent to probably 40 percent.

Storing High-Moisture Corn for Cornage

Concrete stave or poured concrete silos that are in good condition, and airtight silos will all do a satisfactory job of storing cornage. Total dry matter losses have been less than 5 percent of the ensiled material with concrete stave silos in tests at Michigan State University.

In general, dairymen should provide 70 to 80 bushels of ear corn (at 70 pounds per bushel), 80 to 90 bushels of shelled corn (at 56 pounds per bushel) per cow, or equivalent amounts of other grain for milk production. Another 5 to 6 bushels per milk cow will be needed for young stock.

The approximate amount of storage space in bushels of cornage provided by various diameter silos is shown in Table 3. This can be used to estimate silo space requirements for your herd.

Concrete silos used for processing cornage must be in good condition and doors must fit tightly to prevent air from leaking into the mass. For older silos it may be advisable to either caulk the door joints or cover the doors with a strip of plastic film available at most farm supply stores. Reinforce according to manufacturers' recommendations.

The filled silo must be covered with a plastic silage cap. Always crown the surface slightly, make a ditch at the silo edge, lay the cap smoothly over this surface, and tuck the cap down into the ditch and up around the silo. To hold the cap in contact with both silage and silo, fill the ditch with anything which cannot freeze, run out, or blow away. A light weight logging chain can be used. If the cap is close to the top of an open silo, it is advisable to weight it down in the center.

A mechanical distributor or daily leveling of material is recommended. Coning of high moisture material in the silo will increase separation of the whole kernels and larger cob particles.

Table 3 — Approximate Silo Capacities in Standard Bushels per Foot of Silo Height for Various Moisture Contents of Corn.*

(Equivalent 15.5 percent kernel moisture)

Kernel moisture content percent	Conversion factor†	Approximate bushels per foot of silo height. Silo diameter (feet) 10	12	14	16	18	20
SHELLED CORN (1.25 cubic feet per bushel at 15.5 percent moisture)							
15.5	1.0	63	90	123	160	204	251
24	1.08	58	84	114	149	188	234
28	1.13	56	80	109	143	180	223
32	1.18	53	77	105	136	173	214
GROUND EAR CORN‡ (1.94 cubic feet per bushel at 15.5 percent kernel moisture)							
15.5 (16)	1.0	40.5	59	79.5	103	131	162.0
24 (29.0)	1.11	37	53	72	93	119	146.0
28 (34.0)	1.16	35	50	69	89	113	140
32 (38.2)	1.21	34	48	66	86	109	134

* Capacities based on constant density for each cubic foot of silo storage. No allowance made for compaction.

† Mutliply the number of bushels of dry corn (15.5 percent moisture content by the conversion factor to determine the equivalent volume required to yield same dry matter. For example, 100 bushels of dry corn × 1.13 = 113 bushels of 28 percent moisture corn to yield same amount of dry matter as 100 bushels of 15.5 percent corn.

‡ Laboratory tests show density increases with depth. Total storage capacity of silos 40 feet or higher may be 10 percent greater than shown in the table.

§ For ground whole kernel corn, increase storage capacity approximately 14 percent above that shown for whole shelled ear corn.

Handling High Moisture Corn and Cornage

There are several handling systems that can be used for cornage. These factors are important to system operation:

(1) Machinery for harvesting and handling grain into storage is high capacity equipment.

(2) Equipment for removing grain from storage and for processing and distributing grain is essentially low capacity equipment.

(3) A grain high in moisture, such as cornage, is more difficult to handle, resulting in either increased horsepower or reduced volume as compared to forage or dry grain.

(4) Processing ahead of storage can limit the rate of harvest.

(5) High moisture materials bridge easily.

(6) Introducing supplement with cornage ahead of feeding requires some method of mixing.

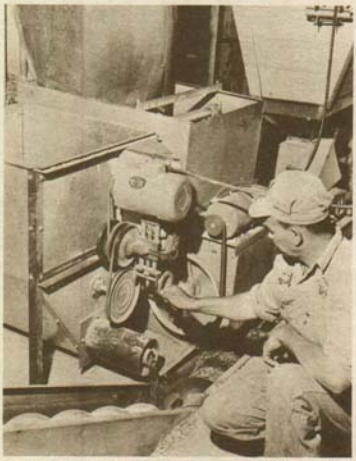
(7) The flexibility of being able to introduce dry corn into the feeding system is highly desirable.

(8) A method of providing grain to dry cows and young stock must be considered.

(9) The decision whether to feed cornage in the feed bunk as well as in milking area, or in the feed bunk only, influences the location of the storage and selection of equipment.

The simplified flow chart, (see above) shows the functions that must be performed by a system for providing the grain ration in the form of cornage. The flow chart will also help identify the components

Cornage is transferred daily from silo storage to floor above milking parlor and dropped in piles over large down chutes to milking stalls. Some gravity flow takes place as shown by holes in center of each grain pile. Operator must rebuild piles over down chutes after each milking. Closed automatic feeding systems that depend on pressure switches for operation do not work satisfactorily as the high moisture material tends to build up and bridge when under pressure.



The hopper-bottom metal bin in foreground, coupled with the variable speed drive unit and changeable size augers in the bin, allow a wide range for metering grain, ground feed, and supplement. The rectangular metal bin (center) with a moving apron as a floor and the hoppered bin serve as meters or flow regulators for silage and cornage.

required. There can be considerable variation in the components. However, to have an efficient and economical operation, the components should be selected to fit a planned system. Volume and the method of grinding are probably the two most important factors in determining the most suitable system for a particular farm.

Grinding

All cornage must be ground prior to feeding. Ear corn must be ground prior to storage. Several possible combinations of equipment for grinding are shown in Table 4.

Field grinding with the machine used for harvesting provides the smoothest flow of material, and simplifies the mechanics of handling at the farmstead.

Machines that can be used for grinding in the field include a tractor-mounted mill in combination with a two-row picker, a harvester with a corn head and screen under cutting head, or a combine with corn heads and a special kit to permit grinding of ear corn.

Roller used for cracking high moisture whole kernel corn. Auger with open screw section on end and variable speed drive acts as meter. High moisture corn unloads into small bins.

Grinding into the silo with a mill frequently requires additional handling and machinery. Many mills will not elevate ground cornage into the silo, thus requiring a blower and a second power unit.

A screen with ½" holes is the most desirable size. Experience has shown that approximately 90 percent or more of kernels will be cracked or broken, and cobs are broken down to a desirable fineness. The ½" screen limits mill capacity and sometimes makes it difficult to keep up with a two-row harvester unless a large tractor is available as a power source. A ¾" screen, for example, allows greater capacity, but will result in larger cob particles and allows more whole kernel in the cornage. With a 1" screen a kernel breakage of approximately 75 percent can be expected. Greater separation of materials will result with the larger screens, both in the silo and in the feed distribution systems. A hammer mill, burr mill, or a blower with recutter unit can be used at the silo for grinding ear or shelled corn.

Where large volumes of shelled corn are handled, it may be simpler to store the kernels whole and grind the corn as it is removed from the silo. Grinding at a sufficient rate to keep up with a picker-sheller

Table 4 — Methods of GRINDING CORNAGE.

	WHERE	HOW
EAR CORN	Field	Tractor-mounted mill fed from picking rolls
		PTO Grinder Combine — if adjustment of concave permits
		Picker with recutter attachment
	Silo into storage	Burr or Hammer Mill, Blower with recutter attachment
SHELLED CORN	Field	Combine if adjustment of concave permits
	Silo before storage	Burr or Hammer Mill or Roller Mill
		Blower with recutter attachement
	Feed center — after storage	Roller mill, Mixer-blender mill, Hammer Mill

A trough-type auger conveyor feeds cornage into a metering hopper-bottom bin. Silage serves as the carrier for high moisture corn. Silage and cornage will be mixed by feeding auger.

Cart is placed under the silo chute and filled by the unloader. Cornage is distributed from the cart in one trip around the stanchion barn.

is difficult, whereas only a low capacity machine is needed for daily grinding prior to feeding. A roller mill or a blender-grinder mill are satisfactory for processing whole kernel cornage out of a silo, using a 2- to 5-horsepower electric motor. A roller mill gives maximum capacity for horsepower required and requires minimum space, making installation possible in fairly close quarters. A roller mill will handle only one grain at a time, however, so it will not serve as a mixer unit.

A blender-grinder mill will meter 2 to 4 materials and blend the materials, usually ahead of grinding. Such a unit will grind more than one grain at a time. Most blender-grinder units use a knife-type hammer for grinding. The fineness of grind is controlled by the screen used in the mill.

Unloading from Storage

The conventional top or bottom unloaders for concrete and gas tight storages work well for shelled corn. Most such unloaders will work satisfactorily for ground ear or shelled corn. However, since these unloaders are designed for forages rather than meals (ground corn), it is desirable to check manufacturers' recommendations for adjustments or attachments.

The success of the auger units placed in the bottom of storage for unloading whole kernel cornage depends largely on the condition of the corn in the storage. With this method of unloading, kernel moisture should be 25 percent or less and free of husks and broken stalks. A distributor should be used as corn is put into storage to prevent a pile-up of chaff and broken kernels.

Distributing and Feeding Cornage

Mechanizing the handling of cornage from storage to feeding has several limitations that are not present in handling dry feed. Closed distribution systems controlled by pressure switches do not work well because the high moisture material will pack and bridge over drop-out chutes and in bins. Also, it is desirable to empty the mechanical handling equipment daily, especially during summer months.

There are several systems that make possible satisfactory and convenient handling of cornage. Each method includes these steps:

(1) Bulk storage and removal (silo and unloader)

(2) Buffer or surge bin (hopper or small bin receiving material from bulk storage)

(3) Flow regulation (by conveyor, hand scoop, or metering device)

(4) Grinding (if whole kernel cornage is stored)

(5) Mixing (if supplement is added to cornage)

The organization and placement of components can vary. For example, a metering unit to regulate the flow of cornage into a feed bunk could be placed (a) immediately under the silo chute with an auger to move grain to feed bunk, (b) in a feed room with an

auger with hopper to move corn from silo chute to metering unit, and a second auger to carry feed to feed bunk, or (c) over the bunk with an auger unit to bring feed from the silo chute.

An over-head conveyor can be used to bring cornage to a milking parlor from a silo located by the feed bunk or to take it from the milking parlor area to a feed bunk. A roller mill can be located either at the silo discharge or over a milking parlor. Silo location should be chosen on the basis of flexibility of total utilization and conveyors used to move the cornage to the point of feeding.

Here are some handling systems that have proven to be satisfactory:

(1) **On feed bunk with silage.** This is the most desirable method from the standpoint of handling. System components include silo, unloader, metering unit, and conveyor linkage to feed bunk. Cornage is mixed with silage or haylage by a mechanical feeder. Selective feeding can be done in a divided feedlot by proper selection of feeding equipment. Additional supplement can be fed in parlors if needed.

(2) **In milking parlor as separate material.** (a) A completely mechanical system can be developed using a live bottom bin and continuous chain feeder. Usually no attempt is made to regulate the amount of grain fed to individual animals, but each cow is given all that she will eat. The components include silo, unloader, conveyor, live bottom bin, continuous chain feeder (chick feeder) around parlor, and drop out tubes to grain feeders. The chain runs continuously, dragging a small amount of feed with it, thus keeping drop tubes full. (b) A partially mechanized system with overhead storage. Approximately one day's supply of cornage is rtansferred to floor above parlors and scooped over large downspouts at each milking, or as often as necessary. Some bridging is likely to occur, so convenient access to storage area is desirable. The components include silo, unloader, conveyor or auger wagon to move cornage to milking parlor loft, and grain feeder with large downspout. (c) A partially mechanized system with storage in parlor. This method is very similar to (b), except that a day's supply of cornage is placed in a grain box in parlor and handscooped into a grain feeder.

(3) **In manger in stanchion barn.** Manual distribution of cornage in manger separately or with silage. System components include silo, unloader, feed cart, and scoop.

Mixing Cornage and Supplement

Adding supplement to ground cornage requires another handling sequence and additional equipment. A horizontal batch mixer is required to add a limited amount of supplement to ground cornage. The vertical mixer is not recommended since most of these units depend on gravity flow to empty and high moisture material will not flow satisfactorily. The uneven flow of cornage from an unloader makes it difficult to add protein through a metering device and produce even a reasonably well-mixed feed.

The blender-grinder mill provides an alternate method of mixing cornage and supplement, using either whole kernel or ground ear corn. Where feed wagons are used for feeding cornage in batches, supplement can be added to the batches as top dressing.

Table 5 — High Moisture Corn Feeding Schedule for Milk Production*.

Milk	Shelled	Ear	Milk	Shelled	Ear
	Pounds per day			Pounds per day	
30	7	8	66	28	30
36	10	11	72	31	34
42	14	16	78	34	38
48	17	18	84	38	42
54	20	22	90	42	46
60	24	26	96	42	Unlimited

* Assumes protein supplement mixed with the high-moisture corn. If corn is fed separately, feed 10 percent less than indicated in the table.

Table 6 — Daily Feeding Requirements Related to Silo Sizes for Grain at 28 percent kernel moisture or ear moisture of 32 percent*.

Pound fed daily per head — dry grain equivalent.†	Number of cattle required to remove 2 inches daily‡					
	Silo diameter in feet					
	10	12	14	16	18	20
Shelled corn						
5	105	151	205	267	340	419
10	52	75	103	133	170	209
15	35	50	69	89	113	140
20	26	38	51	67	85	105
25	21	30	41	53	68	84
Ground ear corn						
5	82	118	159	208	286	325
10	41	59	80	104	132	161
15	27	39	54	69	88	109
20	21	29	40	53	66	81
25	17	24	32	42	53	65

* To detremine size height multiply 2" by number of days and divide by 12" to get feet of height. For example, to feed 103 animals 300 days from a 14' diameter silo: 2" × 300 day = 600 inches divided by 12 = 50 feet plus room for unloader.

† An increase of one percent in moisture content of kernel will reduce the dry weight equivalent or the number of cattle per 2" layer by about 2½ percent. A decrease in moisture will increase the number of cattle by about 2½ percent.

‡ Based on necessary removal to prevent spoilage during fall, winter and spring months. Three to four inches may be required in hot weather particularly at top of silo.

Feeding Considerations

About 1.2 to 1.3 pounds of cornage are equivalent to 1 pound of normal air-dry corn because of the difference in moisture content. Therefore 20 to 30 percent more cornage should be fed than when air-dry corn is used.

Dairymen find properly processed cornage very palatable to cattle. The change to cornage from dry grain must be made gradually, however, to avoid temporary "off-feed". Likewise, the upper limit of intake will vary with individual cows just as it does with dry grain. Proceed cautiously when feeding at high levels. Skip one feeding if a cow appears off-feed, then increase gradually. Lower moisture cornage (24 to 32 percent) has less tendency to cause off-feed at high levels of feeding than higher moisture cornage.

Feeding from the silo immediately after filling results in a gradual transition from fresh corn to cornage and eliminates the sudden change problem.

Cornage can be fed to calves and yearlings with excellent results.

In general, 2 to 3 inches of cornage should be removed from conventional silos daily to prevent deterioration of the product; a faster rate may be desirable in warm weather. Spoilage has not been a serious concern in practical feeding situations.

Silo capacity should be tailored to removal rate for various herd sizes as illustrated in Table 6. Keep the silo diameter small enough to insure removal of 2 to 3 inches daily from conventional silos.

Urea

Feeding grade urea can be added to high-moisture ear corn during ensiling to increase its crude protein content. Research to date indicates that 0.5 percent urea (10 pounds urea per ton) can be safely added to high-moisture ground ear corn with no apparent effect on its palatability. This is enough to increase the crude protein content of the dry matter from about 9.5 percent to about 11.5 percent. Recovery of the urea nitrogen at feeding time will be 90 to 100 percent of that added. Satisfactory mixing of urea and ensilage has occurred when the measured amount of urea has been evenly distributed over the top of the loads. Urea can be added by hanging a calibrated funnel or similar metering device in position to feed into the blower. A good job of grinding to insure uniform distribution and firm packing is necessary when urea is added.

Limestone or Calcium Carbonate

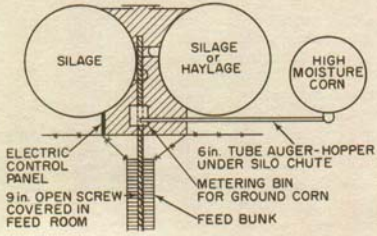
Limited feeding trials with beef cattle indicate an average increase in rate of gain of about 3 percent and 10 percent increase in feed efficiency when limestone treated ear cornage was compared with similar untreated ear cornage.

Direct comparisons on the value of limestone-treated and untreated cornage for dairy cattle are not available. Limestone has not improved the feeding value of whole plant corn silage for dairy cattle.

Water

Water can be added to corn that is less than 25 percent (kernel) moisture at the time of ensiling as high-moisture corn. For a rule of thumb, add 5 gallons of water per ton for each 2 percent of moisture content in the corn below 28 percent. Example: To increase 20 percent moisture corn to 28 percent, add 20 gallons of water per ton ($28 - 20 = 8 \div 2 = 4 \times 5$ gal. = 20 gallons per ton). Grinding shelled corn improves absorption of the water and avoids a musty odor in the cornage when water is added.

SILO STORAGE FOR CORNAGE, HAYLAGE, AND SILAGE
(see picture on front cover)



Silos originally provided storage for an all silage feeding program. Cornage is blended with corn silage, haylage, or both through a hoppered bottom bin meter in a small feed room between the two large silos. This diagram shows the planned feed room for mechanical assembly and mixing of all materials.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture. N. P. Ralston, Director, Cooperative Extension Service, Michigan State University, E. Lansing, Mich. 1P—20M—3:66—WO