University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Historical Materials from University of Nebraska-Lincoln Extension

Extension

1962

EC62-722 High Moisture Grain --Storage and Nutrition--

E. A. Olson

Paul Q. Guyer

Follow this and additional works at: https://digitalcommons.unl.edu/extensionhist

Olson, E. A. and Guyer, Paul Q., "EC62-722 High Moisture Grain --Storage and Nutrition--" (1962). *Historical Materials from University of Nebraska-Lincoln Extension*. 3569.
https://digitalcommons.unl.edu/extensionhist/3569

This Article is brought to you for free and open access by the Extension at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Historical Materials from University of Nebraska-Lincoln Extension by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

AGRI
S
85
E7
#62-722
EC. 62-722
RECEIVED
FEB 12 1963
COLLEGE OF AGRICULTURE
LIBRARY

E. C. 62-722

HIGH MOISTURE GRAIN

--Storages and Nutrition--

E. A. Olson and Paul Q. Guyer 1/

Several types of silos for high moisture grain storage are available. They may be grouped into two general classifications: airtight (sealed) silos and conventional silos. All storages for high moisture grain must be relatively airtight during the storage period. Conventional silos are open at the top during unloading. Airtight silos have sealed roofs and are unloaded at the bottom.

Airtight Silos - How They Work

Airtight silos are made of various materials including glass-lined steel, galvanized steel (usually asphalt coated on the inside), epoxy resin-coated steel, uncoated heavy-gage steel, and epoxy resin-coated concrete. The coating used on steel silos has little to do with the airtightness of the structure, since steel alone is airtight. The coating on steel silos is intended to prevent corrosion by moisture and silage acids. The coating material used on concrete structures serves both to make the concrete airtight and to make it resistant to silage acids.

Recent laboratory research has shown that very low oxygen concentrations (less than one percent by volume) are necessary to provide an environment suitable for storing high moisture grain successfully for periods longer than several weeks. Field measurements of oxygen concentration in airtight silos have borne cut this conclusion.

Oxygen present in an airtight silo at filling time is converted to carbon dioxide within a matter of hours. Oxygen allowed to enter the structure when it is opened for feeding is likewise soon converted. Even daily opening of the structure for feeding does not cause significant spoilage of grain. However, a high carbon dioxide level (above 20%) in the storage indicates that oxygen has been converted and that desirable fermentation is proceeding.

Venting Systems for Airtight Storages

All airtight storages must have some means of pressure control of venting. Pressure in a completely airtight container will vary, due to changes in temperature, radiation from the sun, and barometric pressure. For example, at night when the structure cools, the pressure inside might become less than atmospheric, that is it would "go into a vacuum". Such a condition, if uncontrolled, might cause structural

---

1/ Professor of Agricultural Engineering and Assoc. Prof. of Animal Husbandry, Resp.

This material has been adapted from a paper "Wet Storage and Chemical Treatment of Grain" presented by Dr. G. W. Isaacs of the Agricultural Engineering Dept. of Purdue University at the Crop Conditioning Conference held at the University of Nebraska in August, 1961.

Extension Service
University of Nebraska College of Agriculture
And U. S. Department of Agriculture
Cooperating
E. F. Frolik, Dean E. W. Janike, Director

collapse of a steel silo. Also, if there were any leaks in the silo, (it is probably not economically feasible to make one with absolutely no leaks), pressure below atmospheric in the silo would cause enough air to be brought in to cause spoilage.

Thus it is desirable to have some system of relieving pressures which build up in airtight silos. There are at least three systems that do this. One uses a breather bag and a pressure-vacuum relief valve. The breather bag is in the top of the structure and has a neck connected to the outside air. If pressure inside the structure falls, air is drawn into the bag. If the inside pressure rises, air is forced out of the bag. If the capacity of the breather bag is exceeded, air will be let into the structure through the vacuum relief valve or silo gas will be expelled through the pressure relief valve. Severe weather changes, removal of a large amount of grain at one time, or gas production by fermentation will cause pressure changes great enough to cause operation of the relief valve.

Another pressure relief system consists only of the pressure-vacuum relief valves mentioned previously. As in the above system, air brought in through the vacuum relief valve is diluted with silo gas in the top of the silo, since such valves are located in the roof. This system apparently works satisfactorily where the structure is otherwise reasonably airtight.

Still another pressure relief or venting system consists of a number of gas storage cells or containers connected in series to the top of the silo so that when the silo pressure rises, the silo gas is forced into the storage cells. When the silo pressure drops, the same gas is pulled back into the silo. If the capacity of the storage cells is exceeded by severe pressure changes, air is drawn into the silo as in the other systems. The commercially available version of this system also uses a pressure-vacuum relief valve at the far end of the series of gas storage cells. The gas storage cells are built into the foundation of the silo. Various other systems are being placed on the market.

Unloading Systems for Airtight Storages

High moisture materials such as grass silage, ground ear corn, and even shelled corn are more troublesome to remove from the bottom of storages than dry grain, since they are not free flowing and tend to bridge after settling in the storage. All airtight storages are presently unloaded from the bottom, so stubborn materials such as silage and high moisture ground ear corn must be "mined" from the storage by some form of rugged conveyor. This is presently done in one manufacturer's silo by a chain-flight conveyor in the form of a rotating arm cutting the material loose much like a chain saw and conveying it to the center of the silo where another stationary chain-flight conveyor brings it to the outside. (Another version of this unloader using augers is now being marketed for use on shelled corn.)

All commercial airtight storages have available an auger type unloading system. Auger unloaders have an advantage in low first cost, but are applicable only to shelled corn and grain sorghum. Even high moisture shelled corn can bridge over an auger inlet, but some simple management practices will help prevent any serious difficulties.

Bridging tends to be more severe if shelled corn is allowed to stand in storage several months before feeding is started. Much of the difficulty can be prevented by unloading a few bushels of corn with the auger as filling is completed. This will tend to "orient" the corn for easier unloading later. When regular feeding is not to be started for several months, it is desirable to remove a bushel or two of grain at least once per month to keep the corn in flowing condition.

The multiple auger unloading system is being used widely for shelled corn storages. This system uses from two to five different auger tubes imbedded in the floor of the silo. Each of these tubes has three or more openings into which corn will flow. A single auger and motor-drive assembly is used interchangeably in each of the tubes. Normally, the hole located the farthest from the auger outlet will fill the auger, but if it should bridge over, one of the nearer holes will take over. To limit the horsepower requirements of the auger when there is corn available all over the holes, the auger may be divided into two sections. The additional section is used only after no corn is available at the nearest holes. When all the corn has been removed that will flow by gravity to one tube, the auger is re-inserted into another tube. In this way nearly all of the corn can be removed without shoveling.

Also available commercially is an auger unloader with a flexible joint at the wall so that the auger assembly can be slipped in and out to break bridges or swung around to reach the grain at various points at the bottom of the silo.

All types of airtight silo unloaders must have a resealable outlet port to prevent the entrance of air between feeding periods. It is very important that the gaskets on such ports be carefully maintained. It appears that an air leak near the bottom of an airtight sotrage will cause more spoilage than one near the top. Although daily opening of an airthight silo for unloading purposes will not cause spoilage, a small continuous leak from a faulty outlet cover gasket can cause considerable spoilage.

Conventional Silos

Ensiling ground ear corn in conventional silos has been practiced by some Midwest farmers for many years, particularly in "wet corn years". In very recent years, research at Michigan State University and at the University of Illinois has indicated that high moisture shelled corn also can be stored in conventional silos for feeding purposes.

Additional reinforcing may be needed to withstand grain pressures. Silos built for grass silage should be adequate; however, checking with the silo manufacturer is desirable for prevention of failure.

Since conventional silos are unloaded from the top and are therefore open at the top during unloading, a considerable depth of corn must be removed daily once the silo cap is removed and feeding started. At least three or four inches of material per day must be removed to keep ahead of spoilage. It is possible to re-cap the silo if feeding is interrupted for a long period of time, but this type of storage is generally most adaptable to cattle feeding operations where corn is removed at a relatively high rate for several months. Hog feeders may find that their requirements for corn may vary widely over the year as different lots of hogs are placed on feed. This may make conventional silo storage for shelled corn rather difficult to manage except for relatively large feeders.

Air is prevented from contacting all but the top layer of corn in conventional silos by the high degree of packing that takes place.

Ground or cracked corn packs tighter than whole shelled corn; therefore, shelled corn to be stored in conventional silos should be run through a mill or a high speed blower to crack it. Spoilage at door openings can be prevented by placing plastic over the opening on the inside as the silo is filled.

Mechanical silage unloaders are most desirable for unloading corn from conventional silos. Unloading by hand from the top is not only labor-consuming, but it is difficult to remove an even layer of corn by hand so that a minimum of spoilage occurs. Unloading a conventional silo without a sealed top with any type of bottom unloader should not be attempted. If the material flows out of the bottom, the pack would be broken and considerable spoilage would occur.

Tips for Operating High Moisture Storages

What Moisture Content to Store? Shelled corn to be stored in airtight storage generally should be between 22 and 28 percent moisture. If augers are to be used for unloading, there is less difficulty with bridging below 25 percent moisture. Corn stored in airtight storage above 28 percent moisture will undergo greater changes in color, odor, and texture, and will have higher acidity, although these changes have not been definitely shown to be undesirable. Such corn may tend to spoil faster in the feeder without chemical treatment than that at lower moisture.

Farmer experience with high moisture shelled corn stored in airtight storages between 18 and 22 percent moisture has been varied. Some have encountered no significant spoilage. The reason for these difficulties is not exactly clear to date; meanwhile, farmers are advised to steer clear of this moisture range.

How About Rewetting Corn? Corn that has been rewetted from a lower moisture content apparently stores much the same as corn with its original moisture. The trick is in getting the corn to absorb the moisture. Some farmers have done this successfully with ground corn by putting a water hose into the blower pipe as the silo is filled. Probably the safest way to control the amount of water applied is to re-wet corn in the wagon or truck before it is unloaded. This will prevent any over-watering that would result in water collecting in the bottom of the silo. Over-watering could result in soggy corn at the silo bottom, difficult unloading, and even over-stressing of the silo structure from grain swelling.

Never attempt to rewet corn already in the silo by simply applying a water hose at the top. Uneven distribution of moisture will cause severe spoilage of the grain and even structural failure of the silo.

A large amount of water is required to significantly increase the moisture content of corn. The following table gives the required amounts per hundred bushels of shelled corn:

Original Moisture %	Gallons of water per 100 bushels to increase moisture to 25%
25	0
22	29
20	47
18	64
16	80

Equipment for Filling. High moisture grain storages are most commonly filled with silage blowers. Some are filled with vertical bucket elevators or augers.

Silage blowers generally handle the grain at a high enough rate so that it can be unloaded directly from the wagon or truck with a minimum of delay. They do ordinarily require an extra tractor or engine to operate them. Augers or bucket elevators can be operated at relatively low capacity with an electric motor if a large hopper or pit is used. The elevator can then run continuously between loads and there is no delay in unloading the wagons. One permanent elevator installation can serve more than one silo with the use of spouting or horizontal conveyors.

When silage blowers are used on shelled corn that will be removed from airtight silos with bottom auger unloaders, run the blower as slow as possible to prevent crackage. Excessive crackage will cause bridging over the augers. On the other hand, if storing shelled corn in a conventional silo, the blower should be run at its maximum safe speed to crack the corn for minimum spoilage during top unloading. No appreciable crackage will occur in bucket or auger elevators.

The use of a silage or grain distributor will prevent the separation of cobs from the grain in ground ear corn storages. Such distributors will also help prevent the concentration of fines or trash in shelled corn that may cause some difficulty in unloading the silo, particularly with some auger-type unloading systems. Moving the filling spout frequently will help if no distributor is used.

Sealing Off the Storage After Filling

It is necessary to seal off an airtight corn storage if filling is interrupted for more than an overnight period. Be sure to observe operator safety precautions regarding possible suffocation when entering the top of an airtight silo to level off the fill or to check the breather bag (if your silo has one). Do not fill airtight silos having breather bags so full that the bag is in contact with the material or the bag may be pulled down during unloading and destroyed. The condition of the breather bag should be checked annually.

Check all hatch cover gaskets on airtight storages carefully before installing the covers. If the gaskets have lost their resilience, replace them. Disassemble the relief valve according to the manufacturer's instructions and remove any trash that may have collected there.

Plastic silo caps are generally used to seal off the top of conventional silos for high moisture grain storage. To prevent spoilage of the grain directly beneath the cap, considerable care should be exercised in sealing the cap against the silo wall. One simple method of doing this is to place about a foot of wet ground corn cobs, oats, forage, or similar wet heavy material on the silo crop.

Capacity of Silos for Grain Storage

There appears to be some difference among manufacturers in the method of computing rated bushels of capacity of airtight and conventional silos for grain storage. Some silos are rated on the basis of 1.25 cubic feet per bushel, which if the approximate volume of a bushel of 15 percent moisture grain. When comparing silo capacities, do so on the basis of cubic feet of usable storage capacity.

Capacity in cubic feet = 0.785 x diameter x diameter x usable height.

Diameter and usable height are measured in feet.

For high moisture corn the following figures show the space required for storing one bushel of corn at the moisture contents indicated:

25% - 1.30 cu. ft.

30% - 1.41 cu. ft.

33.5% - 1.48 cu. ft.

Nutritional Value of High Moisture Grain

Table I summarizes data from 15 feeding trials comparing high moisture ground corn with dry ground ear corn for fattening cattle. In 11 trials, high moisture ground ear corn produced more efficient gains than dry ground ear corn with an average of 8% increased efficiency. Rate of gain was not influenced appreciably. In at least one of these trials the high moisture corn was sour, indicating that storage methods were not proper or the rate of feeding was too slow for maintaining good high moisture feed.

Table I. Summary of 15 Experiments Comparing Feeding Value of High Moisture Vs. Dry Ground Ear Corn

Station	Year	Days on Feed	Animals per lot	Percent Moisture		Daily Gain		Conc./100# Gain		Percent Stimulation over dry corn	
				HMC	DC	HMC	DC	HMC 1/	DC	Gain	Eff.
S. Dak.	51	97	18	40	15	2.13	1.78	790	878	19	11
Ind.	56	117	10	32	18	2.47	2.34	866	988	6	14
Ind.	56	117	10	32	18	2.56	2.33	807	951	10	17
Ind.	57	126	36	32	15	2.14	2.18	555	617	-2	11
Iowa	57	119	36	31	15	2.98	3.05	675	750	-2	11
Iowa	58	56	36	38	14	3.34	3.24	471	528	3	12
Ind.	58	133	36	37	24	1.86	1.94	634	660	-4	4
Colo.	58	112	8	53	14	2.41	2.52	433	483	-5	10
Mich.	59	147	10	31	18	1.97	1.53	754	973	29	23
Colo.	59	140	8	55	15	2.08	2.25	519	564	-8	8
Iowa	59	175	6	30	14	2.12	2.31	726	805	-8	10
Iowa	59	175	6	30	14	2.40	2.32	667	634	3	-5
Ohio	59	119	21	36	12	2.15	2.04	685	803	5	15
Mich.	60	203	13	23	19	1.65	1.60	734	725	3	-1
Ill.	60	131	9	36	15	1.50	2.07	947	773	-27	-23
Average	15	131	18	36	16	2.24	2.23	682	742	1	8

1/ Corrected to same moisture content of dry corn.

Data from nine trials comparing high moisture shelled corn with dry shelled corn are presented in Table II. Included in this analysis is one trial where the dry corn was ground (Iowa '60). In these trials rate of gain was usually slightly slower for

the cattle fed high moisture grain. Efficiency of gain was as good or better for the cattle fed high moisture in five trials but the average efficiency was slightly lower for the high moisture corn (moisture content equivalent to the dry corn).

In some of these trials, the feeding rate was perhaps too slow to maintain high quality, high moisture corn.

Table II. Summary of 9 Experiments Comparing Feeding Value of High Moisture Vs. Dry Shelled Corn[1]

Station	Year	Days on Feed	Animals per lot	Percent Moisture HMC	Percent Moisture DC	Daily Gain HMC	Daily Gain DC	Conc./100# Gain HMC 1/	Conc./100# Gain DC	Percent Stimulation over dry corn Gain	Percent Stimulation over dry corn Eff.
Mich.	59	147	10	30	18	2.20	2.21	696	670	0	-4
Ind.	59	98	40	26	18	2.22	2.38	366	375	-7	2
Ill.	59	112	9	37	15	1.51	1.89	832	761	-20	-9
Ill.	59	112	9	29	15	1.91	1.89	754	761	1	1
Ill.	59	112	9	24	15	1.90	1.89	761	761	0	0
Ind.	60	140	40	30	20	1.95	2.09	420	451	-7	7
Mich.	60	203	13	25	19	1.86	1.89	606	629	-2	4
Iowa	60	133	24	35	14	3.56	3.60	688	662	-1	-4
Ill.	60	131	9	31	15	1.81	2.01	867	751	-9	-16
Average	9	132	18	30	17	2.10	2.21	665	647	-5	-2

[1]In one Iowa test, rolled dry shelled corn was used.
2/ Corrected to same moisture content of dry corn.

In several of the above trials, observations showed an appreciable amount of high moisture grain passed through the cattle. Iowa and Michigan scientists estimated that about 1/5 of the amount fed passed through whole and without digestion.

Results of one test comparing ground high moisture shelled corn with the whole grain are shown in Table III. Grinding appeared to increase feed utilization of the high moisture shelled corn by about 16%.

Table III. Effect of Grinding High Moisture Shelled Corn For Fattening Beef Heifers (Illinois 1960)

	Shelled	Ground
Number of Heifers	10	10
Average Daily Gain (lbs.)	1.55	1.58
Corn Required Per Cwt. Gain (15% dry matter basis) (lbs.)	737	618
Increased Efficiency from Grinding (%)	----	16%

Storage of sorghum as high moisture grain appears to be satisfactory also In one Texas trial, high moisture ground sorghum grain produced faster and more efficient

gains than dry ground sorghum grain. Perhaps the lack of dustiness of the high moisture feed was a contributing factor.

Data comparing high moisture grain with dry grain for growing and finishing pigs are presented in Table IV. While results vary considerably, it appears that hogs do better on corn stored with less than 25 to 27% moisture. It is possible that conventional methods of feeding may not be most suitable for feeding high moisture grain to hogs and that modifications in feeding may contribute to more desirable results from high moisture grain.

Table IV. Results Comparing High Moisture Corn Vs. Low Moisture Corn Fed To Swine

Station	Year	How Supp. Fed	Moisture Content HMC	DC	Initial Wt. Lbs.	Percent Stimulation over dry corn Gain	Eff.
Purdue	52	Free Choice	27	13	86	+3.5	-1.1
Purdue	56	Free Choice	32	18	40	-3.6	-10.1
Purdue	57	Free Choice	25	13	104	+8.2	+1.4
Purdue	58	Free Choice	32	18	41	+3.0	-5.0
Purdue	60	Free Choice	29	14	59	-4.1	-6.8
Iowa	58-59	Hand Fed	37	16	51	-4.7	-7.6
Iowa		Hand Fed	29	16	49	-2.8	-4.6
Iowa		Hand Fed	21	16	49	+4.7	+3.7
Iowa		Free Choice	29	14	76	+0.6	+3.1
Iowa		Free Choice	25	14	62	+10.0	+4.8
Iowa		Free Choice	27	14	52	+0.0	+6.5
Iowa	59-60	Hand Fed	32	12	31	-0.6	-3.9
Iowa		Hand Fed	25	12	31	-2.6	+3.9
Iowa		Hand Fed	20	12	31	0.0	+9.3
Iowa		Mixed	32	12	33	+10.0	+3.4
Iowa		Mixed	25	12	33	+19.0	+3.9
Iowa		Mixed	20	12	33	+19.0	+3.5

Comparative Costs of Grain Storage

Table V summarizes a USDA study conducted at the University of Illinois showing comparative costs of handling and storing shelled corn by various methods including airtight storage. Airtight storage is shown to be competitive under the conditions assumed. Individuals making decisions based on cost should obtain cost figures based on their local conditions. In general, it appears that the added cost of airtight storages over conventional storage about balances the cost of drying.

Table V. Estimated Total per Bushel Costs for Field Shelling and Storing High Moisture Shelled Corn Compared with Other Methods. (a)

	Bushels of field-shelled corn						Bushels of corn picked and s red in wood crib	
	Stored in glass-lined airtight bins		Supplemental heat and metal bins		Heated air, concrete stave silo			
	6,000	8,000	6,000	8,000	6,000	8,000	6,000	8,000
	(Cents per bushel)							
Harvest b/	11.3	9.4	11.3	9.4	11.3	9.4	9.3	7.7
Haul & unload	2.5	2.5	2.5	2.5	2.5	2.5	3.2	3.2
Dry c/	----	---	5.7	5.7	10.0	8.4	---	---
Store d/	10.1	9.4	8.1	8.1	4.1	3.6	6.8	6.3
Shell	----	---	---	---	----	---	3.0	3.0
Field loss e/	----	---	---	---	----	---	3.5	3.5
Total	23.9	21.3	27.6	25.7	23.9	25.8	23.8	23.7
Difference f/	0	0	$222	$352	$240	$208	$114	$192

a/ AE - 3450, University of Illinois, June 1959.

b/ Fixed costs are 14 percent of initial investment--mounted picker, $2,700 and sheller attachment, $700. Operating costs are 3.4 cents to field-shell and 3 cents to pick.

c/ Fixed costs are 14 percent of initial investment-burner and fan, $600 per bin for supplemental heat, 2 bins, 6,000, and 3 bins, 8,000 bushels; batch drier, $3,200; and all systems, $22 per year for fuel tank. Operating costs are 2½ cents per bushel.

d/ Cost of glass-lined bins estimated at $6,680 and $8,470 for 6,000 and 8,000 bushel capacities. Costs of circular metal bins include perforated floor and duct work. Ear-corn cribs are estimated at $4,500 and $5,600 for 6,000 - and 8,000-bushel volumes. Space above crib driveway is inclined as ear-corn storage, not small grain.

e/ A charge of 4 percent of gross yield is made for greater field losses.

f/ Difference in per bushel cost between high-moisture corn method and other methods times volume.