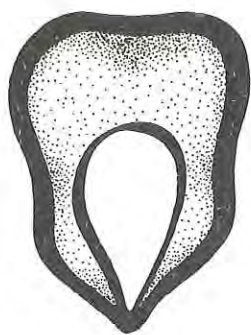


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Preserving and Storing High-Moisture Corn Treated with Propionic Acid

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INTRODUCTION

Traditional methods used to prevent detrimental microbial growth and deterioration of stored corn are to: 1) reduce the moisture content of corn by drying; or 2) ensile corn, thus establishing an acid pH and maintaining an oxygen-free environment. Both of these systems require a considerable initial investment. Increased fuel costs have also increased drying costs.

Treating corn with organic acids, particularly propionic acid or mixtures containing large proportions of propionic acid, is an alternative method of storing high-moisture corn. Although acid can be used routinely, it is usually used to supplement conventional storage.

Applying acid at the proper rate reduces the pH of corn to about 4 and inhibits development of a wide range of microorganisms, including those responsible for spoilage. The amount of acid required depends on the moisture content of corn and length of storage.

There are several advantages to harvesting high-moisture corn. It enables earlier harvesting by 2 to 3 weeks and may reduce labor demands and weather-related losses. Early harvesting also reduces field losses.

Treated corn can be stored in existing bins, in temporary bins, or on plastic on the ground if corn is also protected from rain and snow. Treated high-moisture corn can be transported longer distances without risk of spoilage than untreated high-moisture corn. It can be blended with other feeds in complete rations. Acid treatment reduces insect reproduction. Costs of treatment are usually comparable to those of on-farm drying.

There are, however, some disadvantages to acid treatments: 1) acids should only be used on corn fed to livestock; 2) treated corn will not germinate; 3) acids are corrosive and must be carefully handled; 4) acid treatment does not repel rodents; and 5) it may not be possible to sell treated corn through some commercial channels.

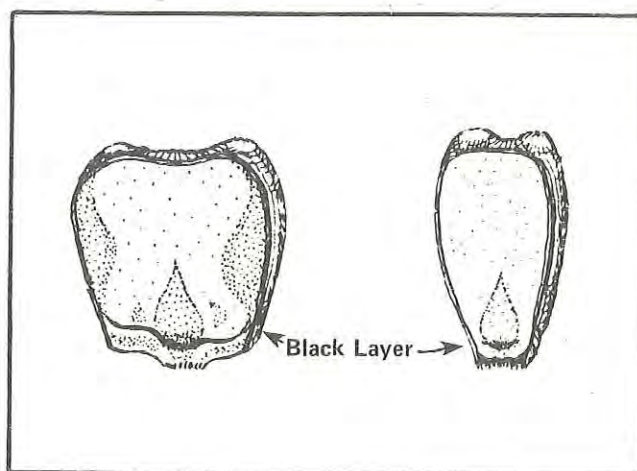
Researchers conducted several trials at the University of Wisconsin Experimental Farms at Arlington and Marshfield to determine the amount of propionic acid needed to preserve: 1) high-moisture shelled corn stored in open bins; 2) high-moisture ground ear corn stored in open bins; 3) high-moisture whole ear corn; and 4) high-moisture ground ear corn stored in upright concrete silos when removal rates were less than recommended. Researchers also studied the acceptability of high-moisture corn treated with propionic acid. Recommendations contained in this fact sheet are, in part, based on findings from these studies reported in Research Bulletin 3057, "Storing and Utilizing High-Moisture Corn Preserved with Organic Acids."

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HARVESTING GUIDELINES

Allow corn to reach physiological maturity so maximum amounts of nutrients have accumulated in kernels. Check for physiological maturity by taking several ears from random locations in the field. Remove several kernels from the center two-thirds of each ear and split the kernels. Do not select kernels from the ends of the ear. If the tips have a black layer, the corn is physiologically mature (see Fig. 1).

Figure 1. "Black Layer"



Corn should be allowed to reach physiological maturity and should be allowed to dry as much as is practical (if weather conditions are favorable) before it is harvested. The lower the moisture content at harvest, the lower the cost of treatment with propionic acid.

APPLICATION

Shelled Corn or Ground Ear Corn Stored in Bins

Before purchasing acid, determine what equipment is needed to apply acid. If possible, rent equipment the first time.

The amount of propionic acid required depends on the moisture content of corn and the intended length of storage. Check the moisture content of grain to determine how much acid must be applied for preservation. Recommended application rates are shown in Table 1. Treat grain immediately after it is harvested to eliminate heating and development of mold.

All application rates in this fact sheet are expressed on a wet basis.

See the sections regarding ensiled ground ear corn and whole ear corn for recommended application rates for those products.

Table 1.
Recommended application rates of propionic acid to preserve high-moisture ground ear corn, ground shelled corn, or whole shelled corn for 6, 9, or 12 months¹

Corn moisture %	Lbs. propionic acid to apply per 100 lbs. wet corn		
	Months corn to be stored		
	6	9	12
20	.33- .50	.40- .60	.50- .75
25	.50- .65	.60- .85	.75-1.00
30	.65- .85	.85-1.10	1.00-1.25
35-40	.85-1.05	1.10-1.40	1.25-1.50

¹ Lower application rates have successfully preserved corn when acid and corn were well-mixed and distributed uniformly. Use higher rates if acid and grain can not be mixed well.

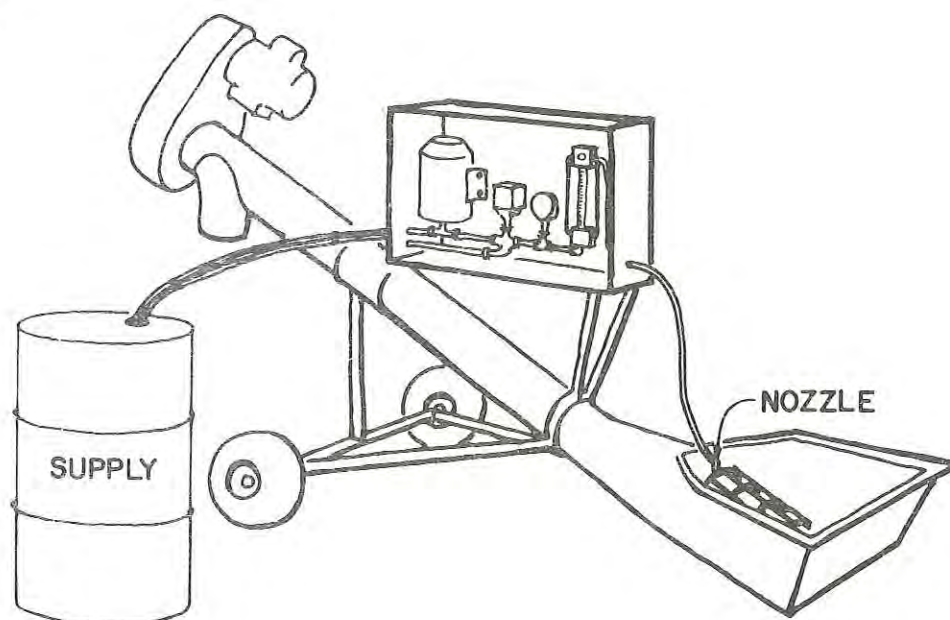
For optimum effectiveness, uniformly apply acid to all particles. Apply acid before any grinding or conveying operation to improve mixing.

Although treated high-moisture corn has been successfully stored for more than 12 months, it is recommended that treated grain be fed within 6 to 7 months after harvest.

Shelled Corn

A typical commercial auger applicator for use on shelled corn is shown in Fig. 2.

Figure 2. Typical auger applicator for use on shelled corn



It is most economical to treat when kernels contain 30 percent moisture, but kernels may be effectively treated if they contain 20 to 40 percent moisture. See Table 1 for application rates.

In storage, treated shelled corn should be aerated at the same rates recommended for dry shelled corn.

Ground High-Moisture Ear Corn

The best moisture level for ground ear corn appears to be when kernels contain 26 to 34 percent moisture at which time whole ground ears will contain 31 to 40 percent moisture. Table 2 shows the relationship between kernel and whole ear moisture content.

Table 2.
Approximate relationship of whole ear corn moisture to kernel moisture¹

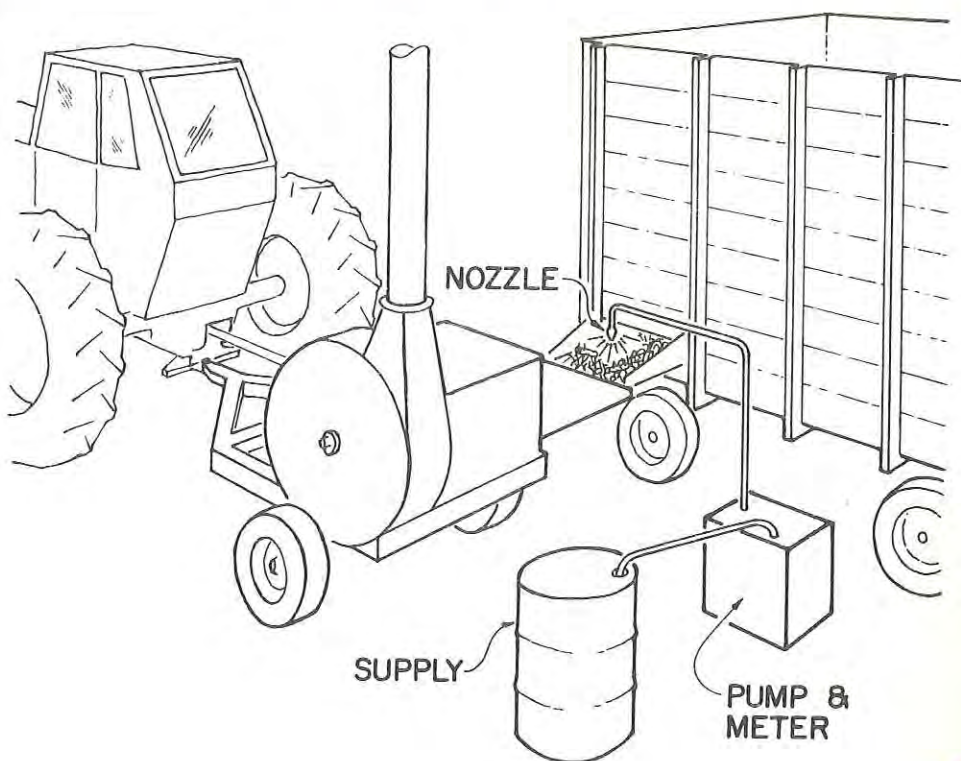
Kernel moisture (%)	Whole ear moisture (%)
22	25-26
24	28-29
26	31-32
28	33-34
30	35-36
32	37-38
34	39-40
36	41-42
38	43-44
40	45-46

¹Derived from Kiesselbach, T. A., Neb. Agr. Exp. Sta. Bul. No. 166 and Davis, Velmar W., University of Ill. Bul. AE3997.

Treated ground high-moisture ear corn can be stored in wooden, metal, or concrete bins if it is protected from snow and rain. Preservatives for ground ear corn are most effective when they are applied to whole ear corn, coarsely ground or rolled material just before it enters the grinder (Fig. 3). Applying propionic acid at any other point is less effective and can lead to hot spots and large mold colonies. Refer to application rates shown in Table 1.

When final grinding is done in the field, it may be necessary to treat ground ear corn when it enters the storage conveyer. If so, the acid may not be well mixed with corn and higher application rates are recommended (see Table 1).

Figure 3. System for application of acid preservative to field-ground corn



High-Moisture Whole Ear Corn

Applying 1.0 percent propionic acid will protect whole ear corn for about 6 months. One percent propionic acid seems to be the optimum level of acid to apply since it is difficult to apply higher levels which might allow longer storage.

Treatment at the 1 percent level gave good protection for 6 months (to May 1) during the University of Wisconsin trials. That is usually an adequate storage time.

Ears do not have to be free of husks, but if more than 20 percent of the ears have tightly bound husks, the effective storage time may be reduced.

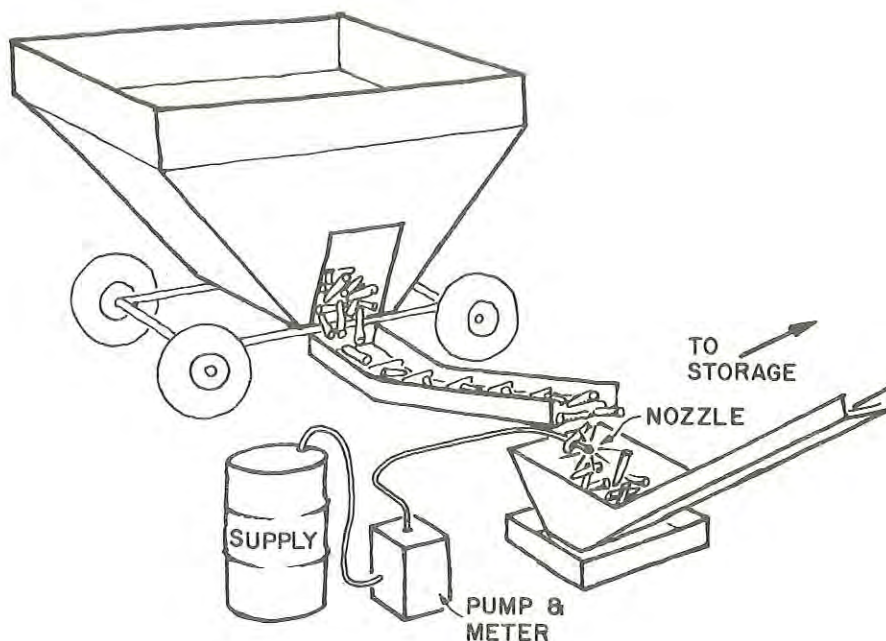
Acid can be applied to whole ear corn at the elevator as it is transferred to storage. A hose pump or a meter-and-pump assembly commonly found on commercial shelled corn applicators can be used (Fig. 2). Adjust the angle of spray so it is at a right angle to corn entering the elevator. The spray should just span the width of the elevator.

About 1 percent propionic acid is the most that can be applied to ear corn by this method. A second treatment would be required for higher application rates. Apply after the first application of propionic acid has soaked into the corn. Since this is not usually practical, higher application rates are not recommended.

Select a nozzle and use a pressure which deliver the required amount of acid and which will produce large droplets. Finely atomized sprays are usually ineffective. Proper application usually requires a pressure of 20 p.s.i. or less. Acid which runs off can be collected, filtered, and reused (see Fig. 4).

High-moisture acid-treated whole ear corn can later be ground and blown into a silo for storage and feeding. Treated whole ear corn also has excellent grinding and mixing qualities and can be used as the base grain in rations.

Figure 4. System for application of acid preservative at the elevator



Ensiled High-Moisture Ground Ear Corn

High-moisture ground ear corn can be successfully stored in upright conventional silos if corn contains the correct amount of moisture, if it is properly ground, and if it is removed at the proper rate. Frequently, the diameter of a silo is too large for the size of herd and not enough corn is removed daily to prevent spoilage.

Removing at least 2 to 2-1/2 inches per day of ensiled ground ear corn will usually prevent spoilage when cobs are ground so pieces are not larger than 1/2-inch and when the corn is relatively free of husks. Ensiled ground ear corn containing more husks should be removed at the rate of 3 to 4 inches per day. It may be necessary to increase removal rates of ensiled ground ear or shelled corn during warm weather to stay ahead of spoilage.

Adding propionic acid to ensiled high-moisture ground ear corn will reduce spoilage associated with low daily removal rates. When high-moisture ground ear corn is stored in upright top-unloading conventional silos and less than 2 to 2-1/2 inches of ensiled material is removed per day:

1. Apply 0.5 percent acid if corn is free of husks and acid can be uniformly distributed.
2. Apply 0.75 percent acid if uniform mixing and distribution in the silo are questionable or if ear corn contains appreciable amounts of husks.

Acid and ground corn are thoroughly mixed by applying the acid directly on the whole ear or shelled corn-coarse cob pieces just before they enter the grinder-blower (Fig. 3). Properly mixing acid with corn is extremely important.

Corn can be coarsely ground in the field and then re-ground. Acid is then applied at the grinder before corn is blown into the silo. This is preferable to applying acid to field-ground corn at the blower. If acid is applied at the blower, use a higher application rate (Table 1).

With All Types of High-Moisture Corn:

1. After the proper application rate has been established (Table 1), apply acid so it covers as much material as possible. Apply acid before corn is ground, conveyed, or before any process which will help mix acid and corn.
2. Treat the corn outdoors if possible. Provide adequate ventilation if corn is treated indoors.

3. After treatment, flush equipment with water or untreated grain to reduce corrosion.
4. Observe **safety** guidelines at all times.

CALIBRATION

If preservatives are applied to materials as they are unloaded, the unloading rate must be determined and must be maintained at as uniform a rate as possible. If the unloading rate is expressed in pounds-per-minute, determine pounds of acid to apply per minute by multiplying the unloading rate by the application rate. For example, if a 3.7 ton load—7,400 pounds—of ground ear corn is unloaded in 8 minutes, the unloading rate is 925 pounds per minute (7,400 divided by 8). At an application rate of 0.7 percent, the applicator should discharge $925 \times .007$ or 6.47 pounds per minute.

Weigh loads if a wagon scale is available. If the load cannot be weighed, estimate the weight by determining the number of cubic feet in the load and then multiply that figure by the following values:

Ear corn—30 lbs/cubic foot.

Ground ear corn—30 to 38 lbs/cubic foot. (Use the lower value when ear corn contains some husks or when ground ear corn is loose. Ground ear corn which has no husks and is finely ground may weigh 35 to 38 lbs/cubic foot if it has been transported a long distance).

Shelled corn (28 percent kernel moisture)—46.5 lbs/cubic foot.

A single flood nozzle is adequate for acid application if it is properly located and adjusted.

To set the applicator, start the pump and determine how much time is needed to catch a quart of material from one nozzle. Refer to Table 3 to determine pounds per minute. If the rate is high, either use a smaller nozzle or decrease pressure on the system. If the rate is low, use a larger nozzle or increase pressure. The best application pressure should be high enough to produce a good spray pattern over the moving material but low enough so droplets are fairly large so wind currents don't blow the spray. Since the specific gravity of most of these preservatives is near that of water, water can be used to calibrate equipment.

Table 3.
Pounds of water delivered per
minute per nozzle determined by
number of seconds required to
catch one quart of liquid

Seconds to catch one qt. from one nozzle	120	90	75	60	50	45	40	35	30	25	20	15	10
Pounds/min- ute/nozzle	1	1.3	1.6	2	2.4	2.8	3	3.4	4	4.8	6	8	12

STORAGE FACILITIES

Treated corn can be piled as high and as wide as is convenient. However, provide access to treated corn so samples at various locations in the pile can be taken periodically to check keeping quality.

Nearly any weather-proofed facility can be used to store treated corn. This includes:

1. Metal bins. Since propionic and other organic acids corrode most metals, such bins should be coated with a good-quality acid-resistant paint. If a suitable paint is not available, coating surfaces with raw linseed oil appears to be the next best alternative. However, bins must be empty before raw linseed oil is applied and the oil requires 3 to 4 weeks to dry. Boiled linseed oil dries in 3 to 5 days but may not be as durable as raw oil. Do not coat bins with conventional paints. Check the coat of paint or oil annually before filling bins.

2. Wooden bins, cribs, and buildings. If possible, it is best to store treated corn in wooden facilities to avoid the risk of corroding metal structures.
3. Quonset-type buildings. Make sure metal is protected from corrosive acid. Cover dirt floors with plastic before storing acid-treated corn.
4. Concrete bins. Coat newly-laid concrete with linseed oil or line with plastic to prevent pitting. Also cover concrete floors with plastic.

HANDLING AND FEEDING

1. Since acid is absorbed by the grain, treated grain is protected after it has been removed from storage and can be mixed with dry grains and other feeds. Such mixtures should be fed within 7 to 14 days.
2. Treated grains can be transported and have been successfully moved from one silo to another. Good packing and distribution are desirable. Re-ensiled material should be fed out reasonably fast to prevent spoilage.
3. Acid-treated high-moisture corn is readily accepted by cattle. Studies at the Marshfield Experiment Station showed that dairy cows offered propionic acid-treated high-moisture ground ear corn consumed more dry matter than cows offered untreated high-moisture ground ear corn that had been ensiled or dried.
4. An adjustment period of 14 to 21 days is suggested when switching from untreated to acid-treated grain. Once cattle have become adjusted, treated grain can serve as the only grain in a balanced livestock ration.

SAFE HANDLING OF GRAIN PRESERVATIVES

Follow safety precautions when preservatives are applied.

1. Follow label instructions.
2. Do not store acids with fuels, lubricants or pesticides. Store acids only in the original container that is tightly closed and make sure bungs remain upright.
3. Organic acids should be used only on grain destined for animal feed.
4. Provide the best possible ventilation when treating grain in a building.
5. Do not allow acid to come in contact with skin or eyes. Wear protective gloves, goggles, respirators or a face shield, and protective clothing when working around acid.
6. Make sure water is available to wash away acid that comes in contact with skin or eyes.
7. When acid contacts occur, drench clothing immediately with water and remove contaminated clothing.
8. Organic acids are flammable, so avoid using acids around fire and keep acids away from any ignition source. Provide good ventilation in areas where it is applied.

EFFECTIVENESS OF OTHER PRESERVATIVES

Several chemicals have been tested as preservatives for high-moisture corn stored in open bins. For more information, see Research Bulletin R3057. Many chemicals are effective when applied according to manufacturers' recommendations.

SUMMARY

Acid treatment of high-moisture corn is an alternative method for temporarily storing excess corn. It also is an alternative when drying equipment or facilities are not available.

Advantages of acid-treated corn include: 1) treated grain can be transported without risk of spoilage; and 2) treated grain can be ground and mixed with other feeds stored for short periods of time (1 to 2 weeks) without risk of heating and molding. In addition, ensiled treated corn does not have to be removed at a minimum rate to avoid spoilage.

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