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Acid Preservatives for High-Moisture Grains

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Certain organic acids when properly used will prevent mold growth and spoilage in stored grains with up to 36 percent moisture.

Propionic and a mixture of propionic and acetic are the principal acids used. They are organic acids which are also produced in the rumen of cattle and important in ruminant metabolism. The small amounts used in grain preservation, however, would likely result in little added nutritional value.

Other acids being tested are formic, butyric, isobutyric, benzoic, and a few salts such as sodium propionate, and ammonium isobutyrate. Salts are less effective pound for pound but are relatively noncorrosive and safer to handle, compared to acids.

Acid-type grain preservatives inactivate fungi (molds) and related microorganisms and continue to prevent mold growth for one year or longer when applied at the proper level and with proper storage conditions. However, keep in mind that acid preservatives are not an antidote for toxins produced by harmful molds which may have been present in the grain at harvest. The acid penetrates the grain kernel and lowers the pH to about 4 or 4.5. The germ of the grain kernel is killed, so there is essentially no respiration or other biological activity. The process is similar to preserving food in vinegar.

Laboratory tests at Kansas State University indicated pH was of less importance in preservation than kind of acid. Lactic acid showed little or no effectiveness as compared to similar levels of propionic or a mixture of propionic and acetic acid.

Advantages

1. The preservative effect of acid is retained after grinding and mixing the grain with supplements. Treated high-moisture grain can be ground and mixed into a ration and held in storage or kept in a self-feeder for a couple of weeks or more without spoilage.
2. Using organic acids does not slow the harvesting operation. Acids can be used in conjunction with heat drying of grain. When combining of grain outstrips drying capacity, the excess can be treated with acids and used for livestock feed.
3. Acid-treated grain can be stored in a barn or other temporary storage facility. If stored outside the treated grain must be protected from weather with plastic covers or by other means.

Disadvantages

1. Acid-treated grains must be used for livestock feed. The grain will not be accepted by elevators or by the grain trade without a price discount.
2. Acids are corrosive to metal or concrete bins. They may corrode steel feeders and other metal equipment such as wagons and augers.
3. Bridging in self-feeders may be troublesome with high-moisture grains.
4. The cost of using organic acids is estimated to be slightly greater than the cost of drying the same grain if metal storage bins are used (Table 1). For grain with moisture over 30 percent, organic acids become uneconomical because of the quantity of acid needed.

Feeding Value

The feeding value of acid-treated high-moisture grain is usually considered to be equal or superior to dry grain for cattle and equal to dry grain for hogs.

In six trials at Iowa State University, high-moisture corn treated with either propionic or ammonium isobutyric acid had the same or slightly greater feed value on a dry matter basis for cattle as heat-dried shelled corn. Dry matter losses during handling and storage were less for acid-treated than for heat-dried corn grain. On the basis of dry matter stored, the acid-treated grain was used from 7 to 11 percent more efficiently than heat-dried grain.

Other studies have indicated the dry matter in acid-treated grain is used more efficiently by cattle than that in heat-dried grain. For example, acid-treated high-moisture corn and milo were similar in feed value to that ensiled when fed to cattle in studies at Ohio, Illinois, and Kansas experiment stations. The dry matter in ensiled high-moisture shelled corn has been used 3 to 5 percent more efficiently than that in dry-shelled corn by beef cattle in many research trials. Ensiled high-moisture milo has often shown a 5 to 8 percent improvement for beef cattle.

Economics

From a cost of storage standpoint, acid treatment appears to have the greater economic advantage when used on an emergency basis for temporary storage or where suitable acid storage facilities already exist. When new storage

TABLE 1. ECONOMIC COMPARISON OF ALTERNATIVE GRAIN STORAGE SYSTEMS FOR 20,000 BUSHELS CORN ON LIVESTOCK FARMS

	Commercial Dry & Store	Dry Batch-in Bin, Store Metal Bins	Acid Treat., Store Metal Bins	High Moisture Air Tight Storage	High Moisture Stave Silo Storage
Harvest Information					
Days[1]	15	18	12	12	12
Beginning Moisture (%)	26	28	28	29	29
Average Moisture (%)	23	23	24	26	26
Harvest Losses (%)	6.5	5.7	5.2	5.0	5.0
"Added" Losses over 5%	1.5	.7	.2	-	-
Drying & Storage Information					
Ending Moisture (%)	14	14	24	26	26
Points Removed	9	8	-	-	-
Drying & Storage Losses (%)	2.0	1.0	-	3.0	5.0
Investment[2]					
Drying Equipment		$ 2,200	$ -	$ -	$ -
Bins or Silos		17,000	19,000	38,000	24,000
Other Equipment		1,700	1,700	4,000	8,000
Other Investment		$20,900	$20,700	$42,000	$32,000
Investment/bushel		1.04	1.03	2.10	1.60
Fixed Costs[3]					
Depreciation		$ 1,240	$ 2,070	$ 2,300	$ 2,000
Interest		940	931	1,890	1,440
Repair		248	224	460	400
Taxes, Insurance		313	310	630	480
Total Fixed Costs		$ 2,741	$ 3,535	$ 5,280	$ 4,320
Fixed Cost/bushel		.137	.176	.264	.216
Operating Costs/bushel					
Hauling & Unloading	.10	.012	.012	.025	.037
Drying Fuel (L.P. 40¢/gal)	-	.046	-	-	-
Electricity	-	.012	.006	-	-
Acid (12 month storage)	-	-	.306	-	-
Drying & Storage Fees[4]	.40	-	-	-	-
Total Operating Cost/bu.	.50	.07	.324	.025	.037
Total Cost/bushel					
Fixed + Operating	.50	.207	.50	.289	.253
Adjustments[5]					
Field Loss (over 5%)	.037	.017	.005	-	-
Storage Loss	.05	.025	-	.075	.125
Feed Eff. (beef credit)	-	-	(.125)	(.125)	(.125)
Labor Differences (?)[6]					
Total Adjustments (Costs)	.087	.042	(.12)	(.05)	0
Net Cost/bushel (Beef)	.587	.249	.38	.239	.253
(Hogs)	.587	.249	.505	.364	.378
Cash Flow/Bushel					
Years to Pay		5	5	8	8
Investment/bushel		1.04	1.03	2.10	1.60
Annual Principal & Intst. Payment[7]		.267	.264	.379	.289
Repairs, Taxes, Insurance		.028	.027	.054	.035
Operating Cost	.50	.07	.324	.025	.037
Total Cash/Bu./Year	.50	.365	.615	.458	.361
Adjustments (Beef)	.087	.042	(.12)	(.05)	0
(Hogs)	.087	.042	.005	.075	.125
Net Cash Flow/Bu. (Beef)	.587	.407	.495	.408	.361
(Hogs)	.587	.407	.620	.533	.486

[1]Harvest 220 acres of 90 bu./acre corn with a 4-row combine.
[2]Investment—storage sufficient for about 21,000-22,000 bushel
Acid treatment: Bin capacity 14% greater than dry corn
Airtight: 25 x 65 silo, auger unloader
Stave: Two 18 x 60 silos sized to remove 4 inches/day top unloader

TABLE 1 (Continued)

[3]Depreciation—Metal bins for storage of acid-treated grain, 10 years
—Other storage bins and silos, 20 years
—Equipment, 10 years
Interest—9%/2 = 4.5%
Repairs—Storage 1%
—Equipment 2%
Tax & Insurance—1.5%
[4]Drying charge 16¢, Storage 20¢ at 2.5¢/month with 10¢ minimum
[5]Adjustments are based on corn at $2.50 per bushel
—High-moisture corn for beef is given a 5% credit for increased feed efficiency
—No storage loss is charged for acid storage, increased energy from acid is assumed to compensate for any loss.
[6]When operator labor value is included it should be based on its value in alternative activities. Credit can be given systems when they result in increased timeliness in other parts of the farm operation.
[7]Amortized loan at 9% interest.

facilities are being considered, acid treatment may not have an economic advantage.

An economic comparison of acid treatment with both dry and other high-moisture storage systems is shown in Table 1. To avoid farm cost variation because of differences in existing structures, the comparison assumes purchase of all new equipment. Most farmers already have some facilities and these must be considered when comparing on a specific farm.

The investment cost of facilities for acid treatment is about the same as for a farm grain-drying system, when metal bins are used in both systems. More storage space is required for wet corn than dry corn. Metal bins used to store acid-treated grain should also be equipped for aeration. Original equipment cost is lower for acid storage in metal bins than for other high-moisture systems.

The fixed cost for acid storage is greater than dry storage in metal bins. Because acid is corrosive to metal bins they are depreciated in 10 rather than 20 years for other storage facilities. The useful life of metal bins can be extended by treating them against acid corrosion. However, this increases their cost. Since silo systems have a higher investment cost they have higher fixed costs than for the acid system.

The acid system has higher operating costs. The cost of acid on a per bushel basis is currently greater than that of drying fuel. Since high moisture silo storage doesn't require drying fuel or acid, the per bushel operating costs are lower for those systems.

When comparing the total cost of acid storage to that of other storage methods, consider differences in losses, labor, and feed efficiency. High-moisture systems, including acid treatment, may result in more rapid harvest which can result in reduced field losses. Also, these systems are credited for having improved feed efficiencies for beef cattle.

When new facilities are considered, total per bushel cost for acid storage appears higher than for other on-farm storage systems. Acid storage, however, can be competitive with commercial drying and storage. Since many farmers already have facilities suitable for storage of acid-treated corn, cost comparisons could change.

Cash Flow—Probably more important than cost, for many farmers, is cash flow—especially for farmers who must borrow to pay for the facilities. When comparing annual cash flow requirements between systems, a critical step is finding the actual loan terms for each system. These vary, depending on the farmer's individual situation.

The example near the bottom of Table 1 assumes that the farmer will borrow 100 percent of the required investment and that he can get a five-year loan on the bin systems and an eight-year loan on the silo systems.

After the loan is repaid, the annual cash flow requirement becomes essentially the operating cost, plus repairs, taxes and insurance. The longer the repayment period, the longer the high level of cash flow will be required.

In years of a short crop, the principal and interest payment must still be made. In these years the cash flow requirement will actually be higher on a per bushel basis because the total payment is spread over fewer bushels. The cash requirement for operating cost will be the same on a per bushel basis regardless of the number of bushels produced.

Acid treatment requires a high operating expenditure because of the cost of acid. However, when used with existing structures for temporary storage, the farmer is not obligated to long term principal and interest payments.

Application

Acids for preserving high-moisture grain should be applied immediately after harvest. In warm weather there will be considerable microbial growth, heating, and off-odors in high-moisture grain a few hours after harvest. Thus, it is recommended that acid be applied to the grain within four to six hours after harvest. Moisture content of 14 percent is high enough for storage molds to damage grains slowly. Higher moisture levels cause faster spoilage. Shelled corn with more than 15 percent moisture cannot be safely stored in conventional bins.

The rate of application of the acid is directly proportional to the moisture level of the grain, length of storage desired, and type of acid used. The amount of propionic to use varies from three to nine fluid ounces per bushel. For winter storage about four to six ounces are needed per bushel of high-moisture grain, and for summer six to nine ounces are required. A larger amount is needed when acetic and propionic are mixed than when propionic is used alone. Approximately twice as much acetic as propionic is needed. Consult the company's literature for the amount of their product needed for different moisture levels in the grain. Table 2 gives the recommended application rates for propionic acid.

TABLE 2. OUNCES OF PROPIONIC ACID TO APPLY PER BUSHEL OF GRAIN

% Grain Moisture	Storage Termination Time: April 1	July 1	Sept. 1
21 or less	3	4	6
22 to 25	4	6	8
26 to 30	6	8	9

The flow rate of acid and grain must be carefully controlled to ensure the distribution of a small amount of liquid throughout the grain. Untreated grain will cause pockets of spoiled grain in a bin. The most reliable point of treatment is prior to the entry of the whole grain into an auger.

Equipment

An applicator to meter acid on the grain can be purchased for $750 or more. If your applicator contains an auger, it will cost about $1,400. The auger is not essential since a 6-inch diamter grain auger works satisfactorily. If ground ear corn is treated, two augers in succession should be used to provide a good mix of the acid with the grain. Most applicators cut off the auger if the acid flow stops to prevent untreated pockets of grain. Applicators usually have a capacity of 1,000 bushels an hour.

A blower should not be used to move treated grain for half an hour or more after treatment, in order to allow time for the acid to penetrate the grain kernels. The wetter the grain, the faster the absorption rate.

Buy or rent a moisture tester, which should be used every morning, since accurate moisture determination is necessary for the correct application of acid. A meter with a testing range of 15 to 35 percent moisture should be used. Moisture testers at a local elevator may not be capable of testing moisture at a level this high. Electronic moisture testers are available. Check the accuracy of the meter by crosschecking a grain sample with a local elevator.

Grain with much trash will not give an accurate reading. The trash should be removed from the sample to get a correct moisture test. Then, estimate the extra treatment needed for the trash by increasing the moisture reading by 15 percent, and use the latter to figure the treatment level. Remember that overtreating is better than undertreating; but overtreating is costly. Ordinary grain augers should be washed out every day to prevent corrosion from the acid.

Storage Facilities

Acid is corrosive to steel, especially galvanized metal. It may also react with concrete, especially in warm weather. Grain bins should be lined with plastic sheets or coated with an anti-corrosive paint or plastic film. Organic acid-treated grain can be stored in wooden, aluminum, or fiberglass bins without protective coating.

Storage of acid-treated high-moisture grain outside in uncovered piles has sometimes been successful. Heavy rains and warm weather are likely to cause extensive spoilage of treated grain in unprotected piles exposed to the weather. Covering the grain pile with plastic will keep off rain and snow, but it will cause moisture accumulation and spoilage at the top of the pile.

Moisture migration is a problem in bins as well as in piles of grain. This migration of moisture occurs when there are temperature differences in various parts of the bin of grain. As the grain pile cools during fall and early winter, the moisture is moved up through the relatively warm center of the pile, and condenses on the cold grain at the top. This causes a wet pocket of grain in the top center of the bin. Grain at the top of the bin may be 10 percentage points higher in moisture than the average moisture for the bin. This condensation at the top of the bin is best avoided by using low-volume aeration to cool the grain uniformly. Moisture migration is most likely in large bins of grain and grains put in during warm temperatures of 60° to 70° Fahrenheit or higher.

One supplier recommends aeration of all volumes greater than 1,500 bushels until grain temperature is below 55° Fahrenheit. The top of the grain pile should be leveled off to reduce moisture condensation in the peaks of the grain. The ventilation of air space above the stored grain is also helpful.

Grain should be checked continually for insect infestation and for hot spots or possibility of grain going out of condition. There is no evidence that acid-treated grains are resistant to insect infestation.

Safety

These acids are mildly caustic and will burn the skin. One should wear goggles, a respirator, and rubber or plastic gloves, shoes, and apron in handling the acids. Leather will absorb acid. Avoid breathing fumes during filling or when entering a freshly treated grain bin a day or two after treatment.

Treat outdoors if possible. Within doors, provide proper ventilation to prevent vapor concentration great enough to cause eye and respiratory irritation. Avoid smoking or having an open flame or heating device in treatment storage areas. A quantity of fresh water should be kept close by in case of an acid spill.

If liquid is spilled on clothing, remove clothing and wash exposed skin area thoroughly. Keep an extra change of clothing near the treatment area. Contaminated clothing should be washed before wearing.

Selling Treated Grain

Acid-treated grain must be used for livestock feed. It will not be accepted by an elevator or other commercial trade channels without a dock. After grain is treated with organic acid, it retains the odor of the acid. This odor diminishes with time, but traces usually remain for the entire storage period.

In addition, a slight sour odor may develop in treated grain in late spring or summer. These odors do not affect its acceptability to livestock. They will, however, cause corn to be graded as sample grade in the commercial trade. This limits treated grain to livestock feed on the farm where it is produced or to sell for livestock feed through channels where no official grading is required.

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