leaks caused by parts failure are safety hazards. The following safety rules should be obeyed when alcohol or alcohol-gasoline blends are used as fuels.

- Don't use fuel to clean parts.
- Don't refuel a running engine or a hot engine.
- Dont' smoke while refueling.
- Don't fill the fuel tank full- leave a little space for expansion.
- Make sure the fuel tank cap is tightened.
- Clean up spills immediately.
- Watch for leaks in fuel lines, pumps, filters, and all seals.
- Check electrical system for frayed wires or loose connections.
- If possible, store gasohol in underground tanks. If storage tank is above ground, locate it in a cool shady place.

The Future

We are deeply concerned about farm fuel supplies. Conservation practices and better management have decreased fuel requirements to a considerable degree. Today we are energy dependent upon foreign countries and some of these countries have strong anti-American feelings. Our nation must consider the steps that can be taken if and when these foreign supplies disappear. There are problems associated with the production and use of ethanol and ethanol-gasoline blends, but these can be overcome. The cost may be higher than present day costs of petroleum based fuels but this may be unimportant if petroleum based fuels are no longer available. The problems associated with ethanol-diesel blends may be quite serious. More information is needed before these blends can be recommended for diesel engines. We are told by scientists employed by oil companies as well as others, that future fuel supplies will be available from coal and oil shale at prices well below those perceived for alcohol production. These supplies may not be available for a number of years however. In the meantime, all alternative fuel sources must be seriously considered. Ethanol produced on American farms from farm products could prove to be one of our valuable fuel sources.

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Distillers By-Products as Cattle and Swine Feeds

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Summary

Wet or dry Distillers Grains and Solubles are valuable feed ingredients for cattle and swine. For cattle the value is variable, but as a simple rule, 2 lbs of distillers dry grain is worth 1 lb of soybean meal plus 1 lb of corn.

The grain appears more useful to cattle, the solubles more valuable for swine. Indeed the wet by-product, a major saving is effected in energy and cost saving. However, the feeding must be within a day or two, and near the distillery.

The major by-product of an ethanol distillery is high protein animal feed. The distilling process does not affect the protein content of the feestock used, so a wet or dry spent grain by-product can contain as much as 30% protein. The wet commodity is taken directly from the processing facility and has a composition of 7% solids and 93% water. This substrate has high transportation costs and a rapid spoilage rate, requiring nearby markets to be profitable. Current prices are in the area of $.53 per cwt of dry material introduced into the production process. (i.e., a distillery utilizing 10,000 pounds of grain per day would sell the post-production mixture for $53.00).

The dry version of this by-product is distillers dried grain (DDG) which has been dried and pelletized immediately following the distilling process. The drying process adds to capital requirements and energy costs (12,000 to 30,000 BTUs per gallon), but the DDG is a far more valuable material because of its storage and handling advantages. Apparently DDG is preferred by livestock to the wet form, adding to its marketability.

Major markets for DDG are cattle feedlots and dairies primarily in central Arizona counties.

This high-protein by-product, is most often utilized as cattle feed. Therefore, transportation to the areas such as Pinal and Maricopa counties become a factor in using these products.

Fermentation of grains to alcohol leaves a residue material referred to as whole stillage, which ranges from 5 to 10% dry matter (DM). This material has been fed to livestock with varying degrees of success. The high water content presents problems in transport and storage. The coarse, unfermented grains can be removed from the whole stillage with a screen and press or centrifuge. These grains will range from 60 to 70% DM depending on the process used. The thin stillage which contains the yeast cells and other soluble nutrients can then be condensed by use of an evaporator.

Condensed solubles may range in DM content from 20-40%. These solubles are currently dried back onto the grains, but there is considerable potential for inclusion of condensed solubles in liquid supplements due to the high phorphorus and nitrogen content. The four main products then are the condensed solubles (CDS), dried solubles (DDS), distillers dried grain (DDG) or the distillers dried grains plus solubles (DDGS). Approximately 40% of DM recovered is soluble and 60% is dried grains.

Nutrient Content

Using grain, the main effect of fermentation is one of starch removal with a resulting concentration of the remaining nutrients (table 1). Approximately two-thirds of the original material is converted to alcohol with one-third recovered as grains and solubles. The grains are converted from high energy feeds for livestock to protein supplements. The energy value of the fermented grains per unit of DM is about 80% of the original material. Removal of the starch triples the percentage of fat, fiber and protein compared to the grain prior to fermentation.

The distillers grains presently produced are used in cattle, swine and poultry rations as well as in specialty products such as pet foods. This paper will deal with the use of the by-products in cattle and swine feeds.

TABLE 1.
NUTRIENT COMPOSITION OF GRAIN AS AFFECTED BY DISTILLATION (DRY BASIS)

		Corn Distillers	
	Corn Grain	Dried Grains	Dried Solubles
Moisture %	11	8	10
Protein %	10	29.5	29.8
Fiber %	2.2	12.8	4.2
Fat %	3.5	8.0	----
Calcium %	.02	.10	.30
Phosphorus %	.32	.95	1.60
TDN %	91	84	84

TABLE 2.
FEEDLOT PERFORMANCE OF CALVES FED DISTILLERS FEEDS AND UREA AS SUPPLEMENTAL NITROGEN SOURCES[a]

Item	SBM	Urea	Urea[b] DDG	Urea[b] DDGS
ADG, lb	2.24	1.87	1.92	1.90
ADF, lb	16.4	16.1	14.4	15.5
Feed/gain	7.32	8.61	7.50	8.16

[a]Trial lasted 112 days, 5 individually fed calves/ treatment.

[b]Urea supplied 50% of the supplemental nitrogen

Nutritional Value for Beef Cattle

Beef animals between the weaning and finishing stages have a fairly high protein requirement. The cost of protein supplements is a substantial portion of total feed costs in cattle operations.

The digestive system of ruminants (cattle, sheep, goats) is basically one of microbial fermentation. The microorganisms digest the fiber and other carbohydrates to produce energy and synthesize microbial protein which is digested in the animals small intestine. These microorganisms also breakdown dietary feed proteins to ammonia and then use this ammonia to synthesize microbial protein.

In theory protein from distillers grain would be worth more than soybean meal (SBM) because the protein in distillers grains resists breakdown by rumen microorganisms. Therefore, some of the protein from distillers grains could be replaced with urea without depressing animal performance. The effects of four protein supplements; SBM, urea, urea + DDG and urea + DDGS on average daily gain (ADG) and feed efficiency are shown in table 2, (Nebraska).

Rate of gain with distillers grains was not much better than urea. Feed efficiency was nearly as good as with SBM, but since half of the distillers grain protein had been replaced with urea, this would be a considerable economic savings. At Nebraska all rations containing distillers grains resulted in weight gains greater than for animals fed urea and greater than or equal to those fed SBM. A summary of research with distillers grain at Nebraska was found to have 173% the value of SBM protein for growing beef cattle, and distillers grains plus solubles protein to be 137% the value of SBM.

The Economics Statistics and Cooperative Service, Washington D. C. has used a figure on the value of the by-product feed distillers grain being worth $120/ton when corn is selling for $2.50 a bushel. If corn is selling for $3.00 a bushel the by-product feed is worth $145/ton. The net effect, the distillers grain is 135% the value of corn. In Arizona, if corn is priced at $100/ton on this equation the distillers grain is worth $135/ton. Workers in Iowa have looked at the value of the distillers grain on a little different basis, and that is this by-product extracted from one bushel of corn is worth a dollar for the feed return from that by-product. On a bushel of corn approximately 18 lbs. of dry material is recovered per bushel and at a dollar for 18 lbs. the value per ton of the distillers grain is approximately $110. So researchers have found some variation in the value of this feed, particularly for dairy and beef cattle, but in every case on the basis of dry matter it exceeds the value of grain and in some cases it may exceed that value by at least 75%. We should be aware, however, that when we use these figures, we are talking about relatively small amounts of alcohol being produced and thus, a limited amount of the distillers by-products available for feedstuffs. For if we get into the large quantities of alcohol being produce we will not have the grain available for our feeding programs. The premium will be on the price of grain, and the distillers grain, high in protein and high in phosphorus will be selling much cheaper. Some predictions as low as $50/ton.

Dairy Cattle

Compared to growing beef cattle, similar or better performance would be expected from feeding these by-products to dairy cattle. The high-producing dairy cow has a high protein requirement especially during early lactation (as high as 18% crude protein). The bacterial protein synthesized in the cow's rumen would provide only a small portion of her total protein requirement. It is necessary then, to have a high proportion of her feed protein escape breakdown and pass through the rumen to the small intestine to be digested. By feeding slowly degraded protein sources such as distillers grains it should be possible to obtain more production from the same amount of protein or the same production with a smaller amount of protein.

A summary of the influence of feeding corn distillers by-products on milk production (table 3) shows a production increase was obtained when distillers by-products were fed compared with the other protein supplements. Distillers grains have an additional value for dairy cattle. Because of the fat and fiber content of these grains (table 1), feeding distillers grains to high producing cows prevents the depression in milk fat percent that often occurs when high grain rations are fed to meet the cow's energy requirement. The influence of feeding distillers grains on milk fat percentage is summarized in table 4. Distillers grains have also been shown to maintain fat test better than corn grain in pelleted grain mixtures. Distillers grains are palatable, highly digestible and suitable for inclusion at a minimum of 40% of the grain ration for dairy cattle.

TABLE 3.
INFLUENCE OF CORN DISTILLERS DRIED GRAIN (± SOLUBLES) ON MILK PRODUCTION

Additional Milk/day (lbs)	Protein source compared
2.9	Cottonseed meal
2.8	Linseed meal
1.7	Hominy feed
1.6	Corn gluten feed
1.2	Urea
.5	Soybean meal
.1	Coconut meal

Warner, R. G. 1970 Proc. Distillers Feed Conf.

TABLE 4.
INFLUENCE OF DISTILLERS GRAINS ON MILK FAT PERCENTAGE

Trial I	SBM	SBM + Fat	Corn DDGS
Milk Fat %	3.88	4.14	4.12
Trial II		Hominy Feed	Corn DDGS
Milk Fat %		2.23	2.54
		3.35	3.49
Trial III		BDG	Corn DDGS
Milk Fat %		3.57	3.61

Warner, R. G. 1970 Proc. Distillers Feed Conf.

DDG is sometimes fed at 5 to 10% of the ration as an appetizer and to mask flavor changes.

Swine

The feeding value of distillers by-products for swine relates closely to its high phosphorus and B vitamin content. Phosphorus is one of the most expensive mineral additives for livestock feeds. Most phosphorus in plant feeds is present in a form called phytate phosphorus. This phytate phosphorus is only 40% available to swine and poultry. Distillers by-products are not only high in phosphorus, but low in phytate, particularly the dried solubles (table 5). In addition, the solubles also contain the yeast cells which are an excellent source of B vitamins needed in swine and poultry rations.

The effect of feeding dried solubles or dried grains plus solubles on weight gain of young pigs is shown in table 6. Adding distillers dried soluble produced greater weight gains than a typical SBM supplemented diet. The dried grains plus solubles was slightly inferior to the solubles alone possibly due to the fiber content of the grains portion. Pigs are not able to digest large quantities of fiber. This indicates a need to separate the grains and solubles and then feed the grains to cattle and the solubles to swine and poultry.

Feeding Wet Grains vs Dry Grains

There is limited information available on feeding of wet distillers grains. The nutritional value is probably similar since drying should not affect nutrient content. Handling grains wet would eliminate the cost of installing and operating drying equipment. However, storage facilities may be a problem since wet grains tend to spoil rapidly. Research is currently under way to evaluate methods of preserving and storing wet grains from alcohol production. The solubles portion may be condensed by evaporation and used in liquid supplements. It may be possible to recycle some of the thin stillage through the fermentation system rather than condensing it.

Feeding Whole Stillage

The feeding of whole stillage at this time has generally been abandoned. The beverage distilling industry found handling and storage too costly. Whole stillage can be fed to livestock but reduced performance may result due to the large amounts of water which must be consumed to get the desired nutrients. Feeding of whole stillage may also result in greater volume of animal waste to be disposed of and there have been reports of oily carcasses resulting from hogs that has been fed stillage.

Whole stillage available from a nearby source does effect some savings in transportation and drying, thus, an overall saving in energy. However, this form of stillage places definite limits on the feeding program. For a large dairy cow 15 gallons of stillage should be the maximum level feed.

For feeding whole stillage to cattle, dry hay should be offered free-choice. Either grass or alfalfa hay would be sufficient, though the alfalfa would reduce the amount of stillage necessary because of its high protein level. Lower quality roughages could be used because of the availability of protein in the stillage such roughages as cottonseed hulls, milo stover, grain straw, etc. It would appear that yearling beef cattle could handle possibly 20 lbs of the wet stillage per head per day. Mature cows as well as dairy cows could handle considerable large quantities of the wet stillage per head per day. Some dry grain in these rations would be needed to be an efficient ration, and for best performance additional vitamin A and D sources should be added to that ration.

For swine, some dry grain plus an additional protein supplement high in lysine and tryptophan is needed. There was work in the late 40's indicating a problem with soft carcasses when stillage alone was fed to hogs in Kentucky, but by adding dry corn to the diet the carcass quality was improved. The use of whole stillage does not appear to be practical in commercial poultry operations.

Our problem in Arizona is, stillage will spoil rapidly because of hot weather, thus, troughs should be cleaned out daily. Sour stillage is unpalatable and can even cause some serious digestive upsets.

TABLE 5.
PHYTATE PHOSPHORUS CONTENT OF SOME COMMONLY USED FEEDSTUFFS

Feedstuff	% Phosphorus Total	% Phosphorus Phytate	Phytate, % of total
Corn	.26	.17	66
Grain Sorghum	.31	.21	68
Soybean Meal	.61	.37	61
Cottonseed Meal	1.07	.75	70
Distillers Dried Solubles	1.43	.10	7
Distillers Dried Grains with Solubles	.77	.33	43

TABLE 6.
EFFECT OF FEEDING DISTILLERS BY-PRODUCTS ON GAINS OF YOUNG PIGS

	SBM	DDS	DDGS
	------ Total Grain, lbs ------		
Trial 1 (8 wks)	54.2	60.4	----
Trial 2 (6 wks)	28.1	29.8	----
Trial 3 (5 wks)	24.6	33.1	30.3

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Arizona Field Crops for Alcohol Production

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Summary

Cereal grains produce about 90 gallons of alcohol (ethyl alcohol or ethanol) per ton, with about one-third of the original weight (nonfermentable material) remaining and suitable for use as high-protein livestock feed. Several different sugar crops have been considered for alcohol production. When sugar is used to make alcohol, about 15 pounds are required to produce each gallon.

Straws, stovers and other high cellulose containing materials may be used as an energy source for distillation, or to produce sugar. At present the conversion of cellulose to sugar is difficult and costly.

Arizona has a history of producing nearly a million tons of cereal grains each year. These are marketed for human food and for livestock feed. While there is some movement of grains across state lines, on balance Arizona is a feed grain deficit state. Use of cereal grains for alcohol production would have an impact on the current markets for these crops. Increased demand and presumably price for cereal grains might result in a shift of part of the acreage now used for other field crops to grains.

Arizona could harvest one-half million tons of stover and straw from land already in field crop production. At present almost all of these high cellulose materials are being returned to the soil for soil improvement but they could be used as an energy source for distillation. Ultimately economical ways may be found to use high cellulose materials to produce sugars and then alcohol. Certain desert plants and forest products may also be suitable for alcohol production.

Most ethyl alcohol (ethanol) in the United States is now made from the cereal grains, principally corn. The alcohol yield from grains varies slightly from one kind to another but is about 90 gallons per ton. About one-third of the original grain weight remains after fermentation for alcohol production. These nonfermentable materials are called brewers grains and are an excellent protein-rich livestock feed.