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Use of by-products of alcohol fuel manufacture

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Quick Facts

Two main by-products of grain alcohol production are a high protein animal feed (distillers' grains) and carbon dioxide.

Distillers' grains are very valuable and readily salable; carbon dioxide is a less salable product.

Distillers' grains may be dried or used wet; each approach has advantages and disadvantages.

Distillers' grains will compete with soybean meal in animal feeding and generally are more valuable than soybean meal on a per unit protein basis.

This is the third in a series of five information sheets on alcohol fuels; other information sheets discuss the basics of alcohol fuel production, raw materials for alcohol fuels, distillation of alcohols, and the economics of alcohol fuel production.

Fermentation alcohol plants produce two principal by-products: the solid residue that remains after the alcohol has been extracted and carbon dioxide. This solid residue, usually called distillers' grains or spent grains, is produced at the rate of about 18 dry pounds per bushel* of corn fermented. It is a valuable material and is commonly used as a livestock feed supplement. The economics of alcohol fuel production are strongly dependent on marketing this valuable by-product. Sales of distillers' grains also help insulate a fermentation alcohol plant from the adverse effects of rising costs of raw materials.

By-product carbon dioxide (CO_2) is much more difficult to sell than distillers' grains. Probably only very large alcohol plants or plants located near a reliable consumer of CO_2 will be able to profit from this by-product.

Distillers' Grains

The by-product stillage from ethanol production is a thin slurry of about 10 percent solids. It consists of the fermented grains and solubles that remain after the alcohol has been removed. Most distillers dry this product and market it as distillers' dry grains with solubles (DDGS). Some researchers recommend, however, that the solubles should not be dried on the grains but should be used separately either in liquid feed supplements or as feed for swine and poultry. They suggest that the grains be used in cattle feed. The amount of DDGS that can be fed to animals is limited because the drying process concentrates acid in the DDGS and makes its taste quite bitter.

If the stillage is not dried, it can be fed to farm animals in several forms: whole (as produced), wet (35 percent to 60 percent solids) or solid (screened). The feeding of whole stillage is limited by the normal daily water intake of the animal and the animal's requirements for metabolizable energy. Also, whole stillage's feeding value to swine and poultry is somewhat limited. Wet stillage (35 percent to 60 percent solids) cannot be preserved for more than a day or two unless stored under CO_2 or ensiled. The major advantage of using stillage directly without drying is eliminating costs of equipment and energy to dry the stillage and produce DDGS. These savings amount to about 20 cents per gallon of ethanol produced. However, dried grains can be transported economically over larger distances and are much simpler for feed manufacturers and farmers to handle. If stillage is not dried, it must be fed locally within a few days of its production. In essence, this requires a captive feeding operation. If the grains are screened from the water and solubles, the water can be used as a fertilizer since it contains significant amounts of nutrients. The wet stillage then can be stored or transported more economically.

Feeding Value of Distillers' Grains and Whole Stillage

The nutrient composition of corn grains, dried grains and dried solubles is shown in Table 1. The U.S. Department of Agriculture uses the chart reproduced in Table 2 to compare the feeding value of DDGS with corn and soybean meal. USDA estimates the commercial value of DDGS at about $110 per ton* (1980 value). The energy content of various distillers' products for feed is given in Table 3. Table 4 summarizes the use of distillers' grains (without solubles) in livestock rations. These figures are based on corn grain as the distiller's raw material.

Researchers at the University of Nebraska have found that distillers' grain products may be worth even more than these figures indicate. The protein in distillers' grains resists breakdown by rumen microorganisms (high bypass protein). Therefore, some of the proteins from distillers' grains can be replaced with urea without depressing animal performance. This is a considerable savings. On the average, distillers' grain protein (DDG) was found to have 173 percent of the value of soybean meal, and distillers' grains with solubles (DDGS) had 137 percent of the protein value of soybean meal.

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Some research also is being done to produce a human-grade protein from distillers' grains. If this proves to be commercially and technically feasible, the overall credit balance would be about 40 cents per gallon of alcohol produced, a very substantial economic benefit.

Carbon Dioxide Utilization

For every gallon* of alcohol produced, approximately 6.3 pounds* of carbon dioxide (CO_2) also will be formed. Carbon dioxide is used in many oil fields to recover additional oil. It also can be chemically combined with hydrogen gas to produce another valuable alcohol called methyl alcohol. Carbon dioxide also is frequently used to preserve the quality of many agricultural products and as a refrigerant. It has obvious uses in the manufacture of carbonated beverages. The use of carbon dioxide will be very site-specific because costs of CO_2 recovery are about equal to the value of the product (about $30 per ton). However, some alcohol fuel producers are located such that they can profitably recover and sell their carbon dioxide.

**To convert to metrics, use the following conversions: 1 pound = .45 kilogram; 1 bushel = .04 cubic meter; 1 ton = 907 kilograms; 1 gallon = 3.8 liters.*

Table 1: Nutrient composition of grain as affected by distillation (dry percent basis).

	Corn grains	Corn distillers Dried grains	Corn distillers Dried solubles
Moisture	11.0	8.0	10.0
Protein	10.0	29.5	29.8
Fiber	2.2	12.8	4.2
Fat	3.5	8.0	—
Calcium	0.02	0.10	0.30
Phosphorus	0.32	0.95	1.6
TDN	91.0	84.0	84.0
NE_{milk} (Kcal/lb)	920.0	880.0	920.0
NE_{gain} (Kcal/lb)	670.0	600.0	670.0

Recovery of dry matter is 33 percent of each input bushel, 20 percent as light grains (DDG) and 13 percent as solubles.

Table 2: Comparison of corn, corn DDGS and soybean meal.

	Corn	Corn DDGS	Soybean meal
Dry matter (%)	88.0	93.8	89.6
Crude protein (%)	8.9	27.0	44.0
Crude fat (%)	3.5	9.0	0.5
Crude fiber (%)	2.9	13.0	7.0
Ruminant digestible protein (%)	5.8	19.3	37.5

Table 3: Energy content of distillers' products for feed.

	Distillers dried grain	Distillers dried solubles	Distillers dried grains with solubles
For cattle: Total digestible nutrients (%)	83.0	80.0	82.0
Megacalories per kilogram	2.19	2.32	2.3
For poultry: Megacalories per kilogram	2.0	2.75	2.62
For swine: Megacalories per kilogram	1.84	2.98	3.39

Table 4: Use of distillers' grains in livestock rations.

	Maximum % of DDG in diet (dry matter basis)	Maximum daily feeding rate for dry DDG (9% moisture)	Maximum daily feeding rate for wet DDG (70% moisture)	Number of animals needed per bushel per day of input to alcohol plant
Swine (finishing pigs)	20%	1.1 lb/animal	3.3 lb/animal	11.0
Beef cattle	20%	4.4 lb/animal	13.3 lb/animal	2.8
Dairy cattle	20%	9.9 lb/animal	30.0 lb/animal	1.2