FUEL ALCOHOL

FUEL ALCOHOL: DISTILLERS DRIED GRAIN–NUTRITIONAL VALUE

The material remaining after fermentation and distillation is referred to as whole stillage, with a dry matter (DM) content of from 5% to 10%. Due to the high water content presenting problems in transportation and storage, the whole stillage is normally separated into several component parts. The coarse, unfermented grains (distillers wet grains) can be removed with a screen and press or centrifuge. The thin stillage, which contains the yeast cells and other soluble nutrients, can then be condensed by use of an evaporator. The grains will range from 30% to 40%, depending on the separation process used, and the condensed solubles may range from 20% to 40% DM. Thus, there can be up to four products: condensed solubles, dried solubles, distillers dried grain (DDG), and distillers dried grain plus solubles (S). Approximately 40% of the dry matter recovered is solubles and 60% dried grains.

Most of the information available on the nutritional value of stillage as a livestock feed relates to the fermentation of corn, milo, wheat, and rye, with corn and milo most frequently researched. Very little information is available on the nutritional value of residues from cull potatoes, beets, and sugar cane. Thus, the following information is based on the fermentation of corn and its byproducts.

Table 1 presents the effects distillation has on the nutritional value of corn. Approximately two-thirds of the original material (starch) is converted into alcohol, with the remaining one-third recoverable as grains and solubles. The corn is converted from a high-energy (carbohydrate) feed for livestock to a protein supplement. Fermentation triples the percentage of fat, fiber, and protein.

Nutritional Value for Beef Cattle

Beef animals between the weaning and finishing stages have a high protein requirement which makes up a substantial portion of total feed costs. A series of experiments was conducted at the University of Nebraska to determine the protein value of DDG for cattle. Results showed that all rations containing distillers grains resulted in weight gains greater than for animals fed urea and greater than, or equal to, those fed soybean meal. In one trial, distillers grains fed alone had the same value as soybean meal, but when fed in combination with urea, were 40% to 50% better than soybean meal. On the average then, distillers grain protein was found to have 173% the value of soybean meal protein for growing beef cattle, and distillers grains plus solubles protein were found to be 137% the value of soybean meal. On the economic side, it was conservatively estimated that 50% of the value of the original grains would be recovered from the distillers dried grains.

Nutritional Value for Dairy Cattle

Studies indicate that an increase in milk production was obtained when distillers byproducts were fed to dairy cattle compared to several other protein sources (cottonseed meal, linseed meal, corn gluten feed, urea, and soybean meal). In addition, because of the fat and fiber content, feeding distillers grains to high-producing cows

CooperativeExtension
College of Agriculture Washington State University Pullman
In cooperation with the United States Department of Agriculture.
Issued in furtherance of the Acts of May 8 and June 30, 1914, by
Washington State Cooperative Extension, J. O. Young, Director

Table 1. Nutrient Composition of Distillers Dried Grain (DDG) and DDG Plus Solubles

		Distillers			
		Dried	Wet	Solubles	
	Corn	Grains	Grains*	Dried	Thin*
Moisture, %	13	8	70	10	97
Crude Protein, %	8.7	27.3	8.9	25.5	0.85
Crude Fiber, %	2.2	12.3	4.0	3.3	0.11
Nitrogen free extract, %	72	41	13.4	42	1.4
Fat, %	3.2	9.1	3.0	9.0	0.30
Ash, %	1.4	2.2	0.7	7.2	0.24
Energy					
TDN, cattle, %	80	78	25	78	2.6
NE gain, Mcal/lb	0.6	0.56	0.18	0.6	0.02
NE milk, Mcal/lb	1.05	0.98	0.32	0.9	0.03
NE swine, Mcal/lb	1.53	1.54	0.53	1.35	0.045
Amino Acids					
Lysine, %	0.20	0.74	0.24	0.90	0.03
Methionine, %	0.18	0.44	0.14	0.60	0.02
Tryptophan, %	0.09	0.20	0.07	0.30	0.01
Leucine, %	0.98	3.20	1.00	2.10	0.07
Isoleucine, %	0.34	0.99	0.32	1.50	0.05
Phenylalanine, %	0.42	0.80	0.26	1.50	0.05
Threonine, %	0.35	0.30	0.10	0.90	0.03
Arginine, %	0.49	0.98	0.32	0.90	0.03
Minerals					
Calcium, %	0.02	0.09	0.03	0.30	0.01
Phosphorus, %	0.27	0.40	0.13	1.2	0.04
Potassium, %	0.32	0.17	0.05	1.8	0.06
Nitrogen, %	1.39	4.37	1.42	4.2	0.14
Magnesium, %	0.14	0.06	0.02	0.6	0.02
Sulfur, %	0.12	0.42	0.14	0.3	0.01
Sodium, %	0.01	0.09	0.04	0.3	0.01
Iron, ppm	25	220	72	540	18
Copper, ppm	3.2	44	28	81	2.7
Zinc, ppm	29	46	15	180	6.0
Manganese, ppm	5.2	22	7.2	72	2.4
Cobalt, ppm	0.02	0.08	0.03	0.3	0.01
Iodine, ppm	0.05	0.05	0.02	–	–
Vitamins					
Niacin, ppm	18	34	11	110	3.7
Riboflavin, ppm	1.0	2.9	1.0	16.5	0.55
Thiamine, ppm	1.6	1.7	0.6	6.6	0.22
Pantothenic acid, ppm	6.2	5.6	1.8	20	0.68
Choline, ppm	525	1,320	430	1,650	155
Vitamin A equiv. IU/lb	950	2,540	760	480	16

*Composition calculated from nutrient content of corn distillers dried grains adjusted to 70% moisture content and corn distillers dried solubles adjusted to 10% moisture content.

Data source: National Research Council, "Atlas of Nutritional Data on United States and Canadian Feeds."

prevents the depression in milk fat percentage that often follows the use of high-grain rations. In summary, distillers grains are palatable, highly digestable, and suitable for inclusion at a minimum of 40% of the grain ration for dairy cattle. Since DDG have a distinct odor and taste, they cannot be added to, or removed from rations randomly without adverse effect on feed consumption and animal performance. In addition, some materials may affect milk flavor, requiring feeding after milking.

Nutritional Value for Swine and Poultry

The feeding value of distillers grains 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 feed is present in a form called phytate phosphorus which is only 40% available to swine and poultry. Distillers byproducts are not only high in phosphorus, but are low in phytate. In addition, the yeast cells in the solubles are an excellent source of B vitamins needed in swine and poultry rations.

Studies on weight gain of young pigs showed that adding distillers dried solubles produced greater weight gains than typical soybean-meal-supplemented diets. The dried grains plus solubles were slightly inferior to the solubles alone, possibly due to the fiber content. Pigs are not able to digest large quantities of fiber.

For broiler rations, diets formulated to contain as much as 20% corn distillers dried grains and solubles produced no amino acid deficiencies, and at five to eight weeks of age, gains were equivalent to, or better than, gains obtained with a basal corn-soybean plus 5% fish meal diet.

Byproduct Consumption and Animal Populations

Some typical quantities of byproducts which might be consumed by various kinds of animals are shown in Table 2. Table 3 shows the number of animals required to consume the stillage produced at various production rates.

Table 2. Animal Consumption of Stillage

Type of Animal	Production rate	lb feed/day	DDG & S lb/day	Stillage in gal/day 10% solids	20% solids
550 lb calf (hay ration)	2 lb/day gain	13.7	5.8	6.3	3.1
770 lb steer	2.8 lb/day gain	19.4	8.5	9.2	4.6
1,300 lb cow	50 lb/day 3.5% milk	37.0	6.6	7.2	3.6
60 lb pig	1.3 lb/day gain	3.3	1.1	1.2	0.6
Pullet					
age: 3.7 weeks		0.13	0.13		
age: 7.5 weeks		0.22	0.22		

From: USDA–Small-Scale Ethanol Production, 1980.

Table 3. Number of Animals Required to Utilize Stillage*

Gal/yr	7,200	30,000	60,000	180,000	360,000
Gal/day	24	100	200	600	1,200
Gal/hr	1	4	8.3	25	50
Type of Animal					
550 lb calf	28	115	230	690	1,365
770 lb steer	19	78	155	465	931
1,300 lb dairy cow	24	100	200	600	1,200
60 lb pig	144	600	1,200	3,600	7,200

*Based on 300 days per year; 24 hr/day production.

From: USDA–Small-Scale Alcohol Production, 1980.

Some Unique Problems of Stillage

- Stillage will produce rations of unique physical form, odor, and palability.Thus, high-production animals must be kept constantly on such rations to maintain the feed consumptions necessary to maximize gain.
- Stillage must be fed within 24 hours to minimize nutrient loss due to decomposition.
- Feed bunks will have to be capable of holding feeds containing large amounts of liquid.
- Cold weather handling of feeds will require freeze protection.
- Flies.

References

"Fuel from Farms–A Guide to Small-Scale Ethanol Production," SERI/SP-451-519, UC-61, Golden, CO 80401, February 1980.

Keinholz, E. W. and D. L. Rossiter, "Grain Alcohol Fermentation By-Products for Feeding in Colorado," Colorado State University, Ft. Collins, CO.

Kuhl, G., Voelker, H., and R. Schoper, "Use and Handling of Alcohol Plant By-Products," EMC 839, South Dakota State University, Brookings, SD.

National Research Council, Committee on Animal Nutrition, Subcommittee on Feed Composition, "Atlas of Nutritional Data on United States and Canadian Feeds," National Academy of Sciences, Office of Information, 2101 Constitution Avenue, Washington DC 20418, 1971.

Poos, M. I. and T. Klopfenstein, "Nutritional Value of By-Products of Alcohol Production for Livestock Feeds," Cooperative Extension Service, University of Nebraska–Lincoln, NE, 1979.

"Small-Scale Fuel Alcohol Production," USDA-001-04124-0, March 1980, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20401.

Ward, G. M. and J. K. Matsushima, "Feeding Value of Dried Distillers' Grains (DDG) in Beef Feedlot Rations," SERI/TR-98340-1, UC-61, June 1980.

Henry Waelti, coordinator, energy Extension programs and James M. Ebeling, agricultural engineer. Published June 1981.