Distillers Grains Feeding Recommendations

BEEF

Summary of Distillers Grains Feeding Recommendations for Beef

- "…WDGS can be added to corn-based rations for finishing cattle at levels ranging from 10 to 40% of total ration dry matter."
- "When added at levels ranging from 10-25% of ration dry matter, WDGS has greater apparent energy value than corn grain."
- "DDGS has an apparent energy value equal to corn grain when fed to finishing cattle at levels ranging from 10 to 20% of total ration dry matter."
- "When CDS is fed to finishing cattle at 10% or less of ration dry matter, its apparent energy value is equal to or somewhat greater than corn grain."

— Dr. Allen Trenkle, Dept. of Animal Science, Iowa State University, *The Advantages of Using Corn Distillers Grains in Finishing Beef Cattle Diets (Iowa Corn Growers Association brochure),* 2004

- "Nebraska and Iowa research suggests that distillers grains (wet or dry) at up to 40% of the diet dry matter can replace corn for growing and finishing cattle."
- "…feeding distillers grain at 15-20% of the diet dry matter has improved average daily gain and efficiency of gain."

— Kent Tjardes and Cody Wright, *Feeding Corn Distiller's Co-Products to Beef Cattle,* South Dakota State University Extension Service Extension Extra, ExEx 2036, August 2002

- "Distillers grains (wet or dry; with or without solubles) can be fed at 10 to 15% of the diet (DM basis) as a source of supplemental protein in backgrounding and finishing diets."
- "When fed at levels higher than 15% of the diet, distillers grains are also an energy source, replacing corn or other grains in the diet. DDG can be fed at levels up to 20% of the diet DM. WDG can be included in backgrounding and finishing diets at levels up to 40% the diet DM."

— Dr. Greg Lardy*, Feeding Coproducts of the Ethanol Industry to Beef Cattle,* North Dakota State University Extension Service Publication AS-1242, April 2003

- "Distillers grains are an excellent ruminant feedstuff...The DG can be fed at 6 to 15% of the diet dry matter, serving primarily as a source of supplemental protein."
- "When fed at higher levels (greater than 15% of the diet dry matter), the byproduct's primary role is as a source of energy replacing corn grain."

— Dr. Terry Klopfenstein, University of Nebraska-Lincoln, *Distillers Grains for Beef Cattle,* National Corn Growers Association Ethanol Coproducts Workshop, Lincoln, Neb., Nov. 2001

The Advantages of Using Corn Distillers Grains in Finishing Beef Cattle Diets

- **Wet corn distillers grains with solubles (WDGS) is an excellent feed for finishing cattle**

Research at Iowa State University as well as other universities has shown that WDGS can be added to corn-based rations for finishing cattle at levels ranging from 10 to 40% of total ration dry matter. WDGS is palatable and readily consumed by cattle. Because the concentration of starch is less than corn grain, WDGS is less likely to cause subacute acidosis in cattle fed low-roughage rations. Quality and yield grades of carcasses from cattle fed WDGS are similar to those fed corn grain. Feeding WDGS did not change sensory values of steaks. When added at levels ranging from 10 to 25% of ration dry matter, WDGS has greater apparent energy value than corn grain. When used to replace part of the corn and supplemental protein, WDGS improves feed conversion and reduces feed cost of gain when cost of WDGS (including transportation and storage) is equal to or less than cost of corn on a dry basis. For each $0.25 increase in corn price/bu, the value of WDGS (30% dry matter) as a feed for finishing cattle increases $3.75/ton.

- **Dry distillers grains with solubles (DDGS) can be fed to finishing cattle to replace protein supplement and corn**

DDGS has an apparent energy value equal to corn grain when fed to finishing cattle at levels ranging from 10 to 20% of total ration dry matter. DDGS also is palatable and readily consumed by cattle. Feeding DDGS does not change quality or yield grades of carcasses. Feed cost of gain will be reduced if the cost of DDGS is not greater than cost of corn grain on a dry basis. For each $0.25 increase in corn price/bu, the value of DDGS (90% dry matter) as a feed for finishing cattle increases $9.50/ton.

- **Condensed distillers solubles (CDS) has value as a feed for finishing cattle**

CDS is a liquid that typically contains 30% dry matter. When CDS is fed to finishing cattle at 10% or less of ration dry matter, its apparent energy value is equal to or somewhat greater than corn grain. Feeding at levels greater than 10% of ration dry matter might reduce feed intake. Feeding CDS has not changed quality or yield grades of carcasses. For each $0.25 increase in corn price/bu, the value of CDS (30% dry matter) as a feed for finishing cattle increases $3.00/ton.

- **Corn distillers grains (DG) as feeds for other classes of cattle**

Less research has been done with other classes of cattle, but the coproducts are excellent feeds to supplement energy and protein of lower quality forages. Because of the low starch content of DG, these feeds have less negative effects than high starch feeds on fiber digestion in the rumen. When fed to supplement low phosphorus forages, the phosphorus in DG will be of value. Potential uses of co-products include creep feed for calves, supplements for grazing cattle, and supplements for low quality forages such as crop residues that might be fed to growing calves, wintering beef cows, or developing beef heifers.

- **Keys to feeding distillers grains (DG) to beef cattle**
    - When price of DG is low compared with corn grain, there are greater profits from feeding higher levels.
    - Make changes in the ration to account for the nutrients being supplied by DG, namely protein and phosphorus.
    - Maintain adequate quantities of effective fiber in rations containing DG for finishing cattle.
    - Keep the supply of WDGS fresh.
    - CDS should be mixed when stored for longer periods of time.
    - Feed finishing cattle to similar final weights as those not fed DG.

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Feeding Corn Distiller's Co-Products to Beef Cattle

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The ethanol industry is currently in the midst of a considerable expansion period in South Dakota and surrounding states. As more ethanol plants are built and begin production, the availability of co-products for livestock feed will increase dramatically.

Co-products may offer the cattle industry a tremendous opportunity to reduce feed costs without sacrificing performance. However, there are significant challenges that must be met before feeding these products.

The majority of the new plants utilize a dry milling process to produce ethanol from corn. Dry milling (mash distillation) involves cleaning and grinding the grain into coarse flour. Then water and enzymes are added, which convert the starch into sugar. At this point the mixture, referred to as "mash," is cooked and sterilized. Once the mash has cooled, yeast is added to begin the fermentation process. Fermentation results in the production of ethanol, carbon dioxide, and residual grain particles called "spent mash." The entire mixture is then distilled to remove the ethanol and centrifuged to remove as much excess liquid as possible.

Dry Milling Co-Products

Liquid removed from the mash is called thin stillage or "sweet water." Thin stillage may be reintroduced into the cooking and distillation processes to extract residual ethanol, sold directly as livestock feed, or dehydrated to produce condensed distiller's solubles (**CDS**), or "syrup." The remaining solid fraction, called wet distiller's grains (**WDG**), may be sold directly as livestock feed or dehydrated to produce dried distiller's grains (**DDG**).

Condensed distiller's solubles are either sold directly as cattle feed or blended with the distiller's grains to produce distiller's grains + solubles. Distiller's grains + solubles are sold in wet (**WDGS**; 30% DM), modified (**MDGS**; 50% DM), or dry forms (**DDGS**; 90% DM).

One of the first challenges in using distiller's co-products is to determine the nutrient content of the co-product used. As with other co-products (soybean meal, soyhulls, sunflower meal, etc.), nutrient concentrations in distiller's co-products can be highly variable. Table 1 contains a list of commonly reported nutrient values for different distiller's co-products.

Some variation in nutrient concentrations results from differences in the nutrient content of the corn used to produce ethanol. Differences in types of yeast, fermentation and distillation efficiencies, drying processes, and amount of solubles blended back into each of the co-products may also result in nutrient variability.

Some plants may provide product specifications with guaranteed nutrient contents; however, these values are only estimates of the minimum or maximum nutrient content of a particular co-product. Testing each load is the preferred option to assess the actual nutrient concentrations of any co-product feed. When feeding co-products that have limited shelf life (CDS, WDG, WDGS), however, this is not a practical option. Therefore, at the minimum, dry matter should be determined to assess how many pounds or tons of dry matter you are purchasing and feeding to the cattle.

Feeding Distiller's Co-Products

Thin Stillage. Thin stillage contains only 5-10% dry matter and can be used to replace water in cattle feeding operations. Research suggests that replacing water with thin stillage reduces dry matter intake without negatively affecting performance.

Cattle need to adapt over time to drinking the thin stillage. Not all cattle will consume the thin stillage, so these animals must be moved to pens with traditional water sources.

Fountains and water lines should be cleaned frequently to prevent microbial growth. Diets must be adjusted to account for the additional nutrients when thin stillage is replacing water. Since the nutrient content can be highly variable, each new shipment of thin stillage should be sampled and analyzed.

Condensed Distiller's Solubles. To produce CDS, thin stillage is frequently evaporated to approximately 70% moisture. Condensed distiller's solubles provide additional protein and energy and add moisture to condition diets.

Experiments at SDSU suggest that the addition of CDS up to 10% of the diet dry matter improves average daily gain and efficiency of gain. Based on a 10% inclusion, a 700-lb steer consuming 18 lb of dry matter per day would get 1.8 lb dry matter from CDS, or 6 lb of CDS on an as-fed basis (Table 2). A 1000-lb steer would be fed 8 lb, and a 1300-lb cow would get less than 9 lb of CDS as fed.

One note of caution: CDS may contain up to 15% fat depending on the source, and beef cattle diets containing more than 6% fat may depress fiber intake and digestion. When CDS is added at over 20% of the diet dry matter to diets that contain feedstuffs already containing 3% fat (such as early bloom alfalfa and corn grain), the dietary fat percentage can become greater than 6% (20% @ 15% = 3%; 80 @ 3% = 2.4%; 3% + 2.4% = 5.4%< 6%).

Distiller's Grains. Distiller's grains with or without solubles are a medium protein feed and can be fed as a replacement for other protein sources (such as soybean meal, sunflower meal, urea, etc.) in beef cattle diets. The protein in distiller's grains is approximately 50% undegraded intake protein (**UIP**), commonly referred to as "bypass protein," and 50% degraded intake protein (**DIP**).

Rumen microbes require a certain level of DIP to effectively digest starch and fiber and synthesize microbial protein. Microbial protein is the primary source of protein for beef cattle; however, forage-based diets may not allow for enough microbial protein production to meet the needs of the animal. Fortunately, much of the UIP provided by different feedstuffs is available for digestion in the small intestine. Often, a combination of microbial protein and UIP is necessary to meet the metabolizable protein requirements.

Cattle consuming poor quality forages generally require DIP supplementation to improve diet digestibility and performance. For older, more mature cattle, supplementing a protein source that is high in DIP may be sufficient to meet nutrient requirements. However, heifers and young cows have greater nutrient requirements and may require UIP supplementation to meet their nutrient demands for growth, gestation, and lactation. Once the DIP requirement for forage digestion is met, supplementation of higher levels of UIP may improve growth of young cattle and reproductive performance.

Supplements can be formulated from a variety of feeds to best meet the DIP and UIP requirements; however, DDG or DDGS can serve as the sole protein source for cattle. When feeding DDG or DDGS as a sole protein source, it is important to remember that higher levels of crude protein must be fed to effectively meet the DIP requirements.

A good rule of thumb is that, to provide similar levels of DIP, it takes 2.7 lb of DDGS to replace 1 lb of 44% crude protein soybean meal.

Distiller's grains are also an effective addition to feedlot diets. Nebraska and Iowa research suggests that distiller's grains (wet or dry) at up to 40% of the diet dry matter can replace corn for growing and finishing cattle.

In many studies, feeding distiller's grains at 15-20% of the diet dry matter has improved average daily gain and efficiency of gain. Including distiller's grains up to 20% of the diet dry matter can usually be accomplished with corn-based diets that contain forages low in protein without creating excess nitrogen excretion.

Kansas and Iowa research indicates that feeding distiller's grains at or above 40% of the diet dry matter may reduce performance and efficiency of gain and/or decrease carcass quality when compared to lower levels. To feed a 700-lb steer consuming 18 lb of dry matter, a ration containing 20% distiller's grains, 4 lb DDG or 12 lb WDG, should be fed (Table 2).

Besides the nutritional benefits of distiller's grains in feedlot diets, the moisture contained in WDG helps to condition dry rations.

In addition to protein, distiller's grains contain highly digestible fiber and fat, resulting in a similar to slightly higher energy value than corn. By providing energy as highly digestible fiber, we can avoid negative associative effects (reduced forage intake and digestibility) associated with feeding starchy (high starch) feeds. Furthermore, the fiber contained in distiller's grains may help prevent digestive disturbances in feedlot cattle.

Since dried and modified distiller's grains are subjected to a drying process, there is the potential for "burning."

While the distiller's grains may not actually burn, prolonged exposure to heat or excess sugar may result in a chemical "browning reaction" that renders part of the carbohydrate and protein unavailable to the animal. This reaction is similar to that of overheated stacked alfalfa hay as a result of air infiltration.

Generally, DDG, DDGS, MDG, and MDGS should have a bright, golden to golden brown color and smell somewhat like beer. If the product has been burnt, it will be considerably darker and have a burnt molasses odor. Suppliers will often discount the price of a burnt product to account for the reduction in feed value.

The price should reflect the decrease in energy and available protein, and to accurately estimate these values the burnt product must be sampled and tested. The lab analysis should include ADIN (acid detergent insoluble nitrogen) to assess the extent of protein damage. Since the ADIN value only represents nitrogen, it must be multiplied by 6.25 to calculate the appropriate protein value. The calculated protein value represents the amount of crude protein that is unavailable.

For example, if a sample contains 1.2% ADIN, then the unavailable protein value is 7.5% (1.2 x 6.25). Thus, if the sample contains 30% crude protein, only 22.5% crude protein is available (30 - 22.5).

Mineral Considerations

When feeding distiller's grains, keep in mind how the mineral concentrations of the diets are affected. Distiller's grains are low in calcium (Ca) but high in phosphorus (P) and sulfur (S). Feeding distiller's grains may provide enough P to allow supplemental P sources to be removed from mineral packages for cattle consuming forage-based diets.

Feedlot diets generally contain excess P due to the high levels of corn, so, when distiller's co-products are utilized, the additional P must be considered when formulating waste management plans. Also, to facilitate proper performance and to avoid urinary calculi (water belly), Ca to P ratios should be equal to or greater than 1.2:1 but not greater than 7:1. Supplemental Ca can be provided from feedstuffs high in Ca (alfalfa), but it is more commonly supplemented as limestone.

Distiller's grains are also frequently high in sulfur. Excess dietary S can be a problem for ruminants for two reasons.

First, high levels of sulfur (above 0.4% of diet dry matter) from feed and water can lead to polioencephalomalacia (PEM), or "brainers." Second, sulfur interferes with copper absorption and metabolism. This antagonism is exacerbated in the presence of molybdenum. Producers in regions prone to high sulfate water should exercise caution if using distiller's grains in their supplements.

Storage Considerations

Storage is also a major challenge when using co-products. Since CDS and thin stillage contain a high percentage of moisture, they will gel and freeze in cold temperatures. Storage equipment to prevent these products from freezing is necessary. Storage tanks should either be buried or heated for long-term storage in the winter.

Some of the solids in these products can also separate from the liquid. Therefore, the ability to re-circulate or agitate the tank may also be advantageous for long-term storage.

Wet distiller's grains with or without solubles contain about 70% moisture, which makes them challenging to store. This product can freeze into softball size clumps during the winter, making mixing the ration more difficult and and the resulting feed less consistent.

Handling WDG in warmer weather can be even more challenging. Wet distiller's grains will mold and go out of condition in as few as 4 days, although typically, WDG have about 7 days of shelf life before going out of condition. Organic acid may extend shelf life, but the additional cost needs to be considered.

Wet distiller's grains have been successfully stored for more than 6 months in silage bags, either bagged alone or in combination with another feed to increase bulk. SDSU researchers have been very successful storing blends of WDG (70% as-fed; 50% of dry matter) and soybean hulls (30% as-fed; 50% of dry matter).

Dried distiller's grains, with or without solubles, are easier to store since they only contain 10-12% moisture. These products do have a small particle size, so storing DDG out of the wind is critical. Commodity bins or bulk storage sheds work best. Even though DDG have high levels of fat, rancidity during summer months is usually not a concern.

Economics

When determining the economic value of the co-products, comparisons should be made on an energy (Total Digestible Nutrients; **TDN**) and crude protein (**CP**) basis. Table 3 illustrates what could be paid for the various distiller's co-products to replace corn on an equivalent energy basis. The equivalent values of the various co-products compared to soybean meal on a CP basis are presented in Table 4. Keep in mind these economics do not account for any additional costs associated with freight or storage; these expenses should be carefully evaluated when deciding on the value of any feedstuff.

Summary

Distiller's co-products offer beef producers an opportunity to potentially decrease their unit cost of production while maintaining similar levels of performance.

The nutritional characteristics of distiller's co-products (high energy and medium protein levels) allow these feeds to be effectively incorporated into many feeding scenarios for many types of cattle. However, use of distiller's co-products does require consideration of nutritional properties, storage, and, most importantly, economics. Careful assessments of nutrient, shipping, and storage costs are essential when deciding if distiller's co-products are economically viable alternative feeds for your operation.

Table 1. Nutrient concentrations of corn co-products expressed on a dry matter basis[a]

	CDS	*WDG*	*MDGS*	*DDG*	*DDGS*
Dry matter (DM), %	30-50	25-35	50	88-90	88-90
Crude protein (CP), %	20-30	30-35	30-35	25-35	25-32
Degradable intake protein (DIP), % of CP	50	45-53	45-53	40-50	43-53
Fat, %	9-15	8-12	8-12	8-10	8-10
Neutral detergent fiber (NDF), %	10-23	30-50	30-50	40-44	39-45
Total digestible nutrients (TDN), %	75-120	70-110	70-110	77-88	85-90
Net energy for maintenance (NEm), Mcal/lb	1.00-1.15	0.90-1.10	0.90-1.10	0.89-1.00	0.98-1.00
Net energy for gain (NEg), Mcal/lb	0.80-0.93	0.70-0.80	0.70-0.80	0.67-0.70	0.68-0.70
Calcium, %	0.03-0.17	0.02-0.03	0.02-0.03	0.11-0.20	0.17-0.26
Phosphorus, %	1.3-1.45	0.5-0.8	0.5-0.8	0.41-0.80	0.78-1.08

[a]Adapted from the National Research Council and industry publications.

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Table 2. Maximum inclusion rate of rates of co-products for different cattle types

		Co-product maximum inclusion rate (lb)			
Cattle Type	*Weight range (lb)*	*WDG*[a]	*MDGS*[a]	*DDG*[a]	*CDS*[b]
Growing calf	500 – 700	10 – 12	5.5 – 7	3 – 3.5	4 – 6
Finishing steer	900 – 1200	15 – 20	9 – 12	4.5 – 6	7.5 – 10
Cow	1200 – 1500	16 – 20	9.5 – 12	5 – 7	8 – 10

[a] Assuming maximum inclusion rate is 20% of dry matter intake; WDG, 30% DM; MDGS, 50% DM; DDG, 90% DM.

[b] Assuming maximum inclusion rate is 10% of dry matter intake; CDS, 30% DM.

Table 3. Equivalent value of co-products compared to corn on an energy (TDN) basis[a]

	Co-products ($/ton)				
Corn ($/bu)	*CDS*	*WDG*	*MDGS*	*DDG*	*DDGS*
1.50	20.09	18.26	30.44	54.79	60.27
1.60	21.43	19.48	32.47	58.44	64.29
1.70	22.77	20.70	34.50	62.09	68.30
1.80	24.11	21.92	36.53	65.75	72.32
1.90	25.45	23.13	38.56	69.40	76.34
2.00	26.79	24.35	40.58	73.05	80.36
2.10	28.13	25.57	42.61	76.70	84.38
2.20	29.46	26.79	44.64	80.36	88.39
2.30	30.80	28.00	46.67	84.01	92.41
2.40	32.14	29.22	48.70	87.66	96.43
2.50	33.48	30.44	50.73	91.31	100.45

[a] Assumptions: corn, 88% DM and 88% TDN; CDS, 30% DM and 97% TDN; WDG, 30% DM and 88% TDN; MDGS, 50% DM and 88% TDN; DDG, 90% DM and 88% TDN; and DDGS, 90% DM and 97% TDN.

Table 4. Equivalent value of co-products compared to soybean meal (SBM) on a crude protein basis[a]

Co-products ($/ton)					
SBM ($/ton)	*CDS*	*WDG*	*MDGS*	*DDG*	*DDGS*
150	26.33	33.71	56.18	101.12	94.80
160	28.09	35.96	59.93	107.87	101.12
170	29.85	38.20	63.67	114.61	107.44
180	31.60	40.45	67.42	121.35	113.76
190	33.36	42.70	71.16	128.09	120.08
200	35.11	44.94	74.91	134.83	126.40
210	36.87	47.19	78.65	141.57	132.72
220	38.62	49.44	82.40	148.31	139.04
230	40.38	51.69	86.14	155.06	145.37
240	42.13	53.93	89.89	161.80	151.69
250	43.89	56.18	93.63	168.54	158.01

[a] Assumptions: soybean meal,89% DM and 48% CP; CDS, 30% DM and 25% CP; WDG, 30% DM and 32% CP; MDGS, 50% DM and 32% CP; DDG, 90% DM and 32% CP; and DDGS, 90% DM and 30% CP.

AS-1242

Feeding Coproducts of the Ethanol Industry to Beef Cattle

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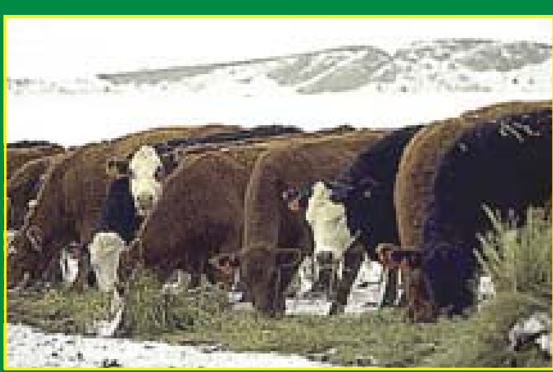

Ethanol industry coproducts, such as dried distillers grains, wet distillers grains and condensed distillers solubles (syrup) are becoming increasingly available as the ethanol industry expands. The purpose of this bulletin is to provide information on the feeding value of these coproducts for beef cattle and give cattle producers guidelines for their use in beef cattle rations.

The ethanol industry in the United States is expanding rapidly, consequently, the amount of coproducts available for livestock feed is also expanding at a rapid rate. In North America, about 3.2 million metric tons of dried distillers grains plus solubles are produced annually. Minnesota, North Dakota and South Dakota produce about 900,000 tons annually. About 80% of this product is fed to ruminant animals.

Ethanol Coproducts

Corn contains approximately 61% starch, 3.8% oil, 8% protein, 11.2% fiber and 16% moisture. During ethanol production, starch is converted to ethanol and the other constituents of the corn kernel become coproducts. Each bushel of corn produces 2.7 gallons of ethanol, 18 pounds of dried distillers grains plus solubles and 18 pounds of carbon dioxide.

Wet and Dry Distillers Grains

Figure 1 diagrams the ethanol production process in a dry milling operation. Coproducts resulting from this process can include dry distillers grains (DDG), dry distillers grains with solubles (DDGS), wet distillers grains (WDG), wet distillers grains with solubles (WDGS) and condensed distillers solubles (CDS). Whole stillage, which is the liquid fraction remaining after ethanol production, is centrifuged to remove coarse solids and then evaporated to produce thin stillage. Thin stillage is further evaporated to produce CDS (sometimes referred to as syrup). The solids portion may be sold wet as WDG, combined with CDS and sold as WDGS, dried and sold as DDG, or combined with CDS, dried and sold as DDGS.

The WDG and WDGS are approximately 30% dry matter (DM; 70% moisture) while the DDG and DDGS are approximately 90% DM. The wet coproducts (WDG or WDGS) have greater energy than DDG or DDGS because some of the volatile compounds can be given off during the drying process. However, protein quality does not seem to be affected by drying. Some processing plants may also market modified wet distillers grains plus solubles (MDGS), which are a partially dried product and are approximately 50% DM. Due to the high moisture content, transportation costs must be considered when purchasing WDG or MDGS.

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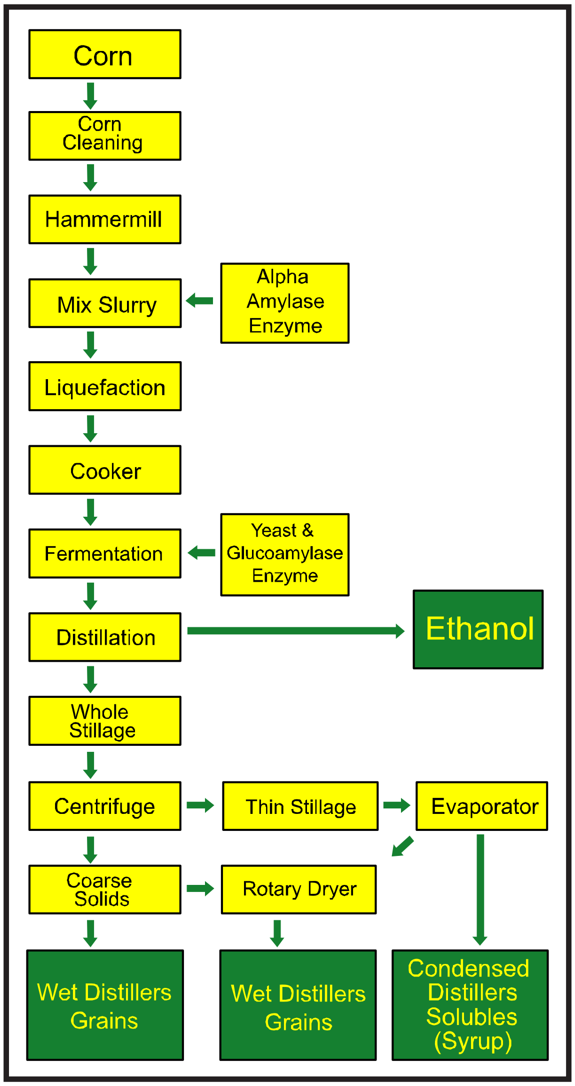

Figure 1. Ethanol and related coproducts production process diagram.

Condensed Distillers Solubles (CDS)

This syrup-like product remains after thin stillage has undergone partial evaporation. Thin stillage is the liquid (5% DM) product that remains following removal of wet distillers grains. Thin stillage is condensed through evaporation to produce condensed distillers solubles (23 to 45% DM). Condensed distillers solubles contain approximately 20 to 30% crude protein on a dry matter basis. Due to their liquid nature, condensed distillers solubles can be used to control dust and condition dry rations (similar to liquid molasses products). In most cases, condensed distillers solubles should be limited to 10% or less of the diet (DM basis; approximately 8 to 10 pounds per head on a wet basis).

Nutrient Content of Ethanol Coproducts

Table 1 gives the average nutrient content for WDGS, MDGS, DDGS and CDS. Distillers grains are relatively high in crude protein, high in fat and are an excellent source of energy and protein for beef cattle. Distillers grains have a fermented aroma and are very palatable. Similar to corn value, the protein in corn distillers grains is high in escape protein (50 to 60% of the cp). Escape protein is not fermented in the rumen but is digested by the animal in the small intestine. Escape protein has some benefit in feeding programs where high performance is expected or where less than optimum levels of escape protein are provided in the diet.

Ethanol coproducts are high in potassium, phosphorus and other minerals. Feeders should reduce or eliminate supplemental phosphorus, potassium and sulfur when high levels of these byproducts are fed. Increased levels of calcium should be considered in order to keep the calcium to phosphorus ratio in the diet at 2.0:1.0. Elevated levels of phosphorus in these coproducts may contribute

Table 1. Nutrient composition of ethanol coproducts.

Nutrient	Dried Distillers Grains	Dried Distillers Grains plus Solubles	Modified Distillers Grains plus Solubles	Wet Distillers Grains	Condensed Distillers Solubles
DM, %	88 to 90	88 to 90	50	25 to 35	23 to 45
DM Basis					
TDN, %	77 to 88	85 to 90	70 to 110	70 to 110	75 to 120
NEm, Mcal/cwt	89 to 100	98 to 100	90 to 110	90 to 110	100 to 115
NEg, Mcal/cwt	67 to 70	68 to 70	70 to 80	70 to 80	80 to 93
CP, %	25 to 35	25 to 32	30 to 35	30 to 35	20 to 30
DIP, % CP	40 to 50	43 to 53	45 to 53	45 to 53	80.0
UIP, % CP	50 to 60	47 to 57	47 to 57	47 to 57	20.0
Fat, %	8 to 10	8 to 10	8 to 12	8 to 12	9 to 15
Calcium, %	0.11 to 0.20	0.10 to 0.20	0.02 to 0.03	0.02 to 0.03	0.03 to 0.17
Phosphorus, %	0.40 to 0.80	0.40 to 0.80	0.50 to 0.80	0.50 to 0.80	1.30 to 1.45
Potassium, %	0.49 to 1.08	0.87 to 1.33	0.70 to 1.00	0.50 to 1.00	1.75 to 2.25
Sulfur, %	0.46 to 0.50	0.37 to 0.46	0.38 to 0.70	0.46 to 0.70	0.37 to 0.95

Table adapted from:
1) Stock, et al. 1995. Average Composition of Feeds Used in Nebraska. G1048. http://www.ianr.unl.edu/pubs/beef/G1048.pdf
2) Tjardes and Wright. 2002. Feeding Corn Distiller's Co-Products to Beef Cattle. South Dakota State University. ExEx. 2036.
3) NRC. 2001. Nutrient Requirements of Dairy Cattle.
The analyses given in this bulletin are an average of published values and regionally available laboratory analyses. Products vary and this may not represent what a particular plant is producing at any give time.

to high levels of phosphorus in the manure and increase in the amount of land requied for proper nutrient management.

In areas where high sulfate water is a problem, the high sulfur levels in ethanol coproducts may create problems with polioencephalomalacia (PEM). This disease affects the neurological system. Producers should consider elevating supplemental levels of copper and thiamine if diets high in ethanol coproducts will be fed for extended periods of time.

The type and nutrient content of coproducts produced by ethanol plants will vary. Routine sampling and laboratory analysis is recommended in order to effectively use these coproducts. Moisture level in the wet coproducts does vary, consequently, a dry matter (moisture) analysis is one of the most important routine analyses to conduct. Producers may also ask the plant for a recent laboratory analysis. The analyses given in this bulletin are a range of published values and industry laboratory analyses and may not accurately represent what a particular plant is producing at a given point in time.

Results from Feeding Trials

Numerous research trials have evaluated DDG, WDG, WDGS and CDS as ration ingredients for beef cattle. Based on these research trials, it appears that WDGS have a greater energy value than corn. The energy content of WDGS depends on the level fed, the source of raw material for the ethanol facility (corn vs. other cereal grains), and possibly the moisture content of the material. Based on animal performance, the energy level of WDGS is at least 125% the energy level of corn.

Research comparing the feeding value of dry distillers grains and wet distillers grains indicates that wet distillers grains are higher in energy than dry distillers grains. Reasons for the lower energy values for dried distillers grains could include 1) inclusion of some residual ethanol in the wet product, 2) moisture content of the wet distillers grains, 3) a reduction in subacute acidosis when wet distillers grains are fed, or 4) heat damage during drying. Most available research indicates the energy content of dried distillers grains is slightly lower than corn.

Research with CDS and thin stillage indicate that these liquid coproducts have greater energy content than corn. Research conducted at the University of Nebraska indicates that inclusion of CDS in the diet improves ruminal fermentation by increasing starch and lactic acid utilizing bacteria. This suggests CDS improve animal performance by altering ruminal fermentation and enhancing starch digestion while reducing acidosis.

Feeding Recommendations

Backgrounding and Finishing Diets

Distillers grains (wet or dry; with or without solubles) can be fed at 10 to 15% of the diet (DM basis) as a source of supplemental protein in backgrounding and finishing diets. When fed at levels higher than 15% of the diet, distillers grains are also an energy source, replacing corn or other grains in the diet. Dried distillers grains can be fed at levels up to 20% the diet DM. Wet distillers grains can be included in backgrounding and finishing diets at levels up to 40% the diet dry matter. However, at these levels, diets will contain excess protein and phosphorous, which may have manure nutrient management implications for many cattle feeders. Most research data indicates the optimum level of wet distillers grains is 25% or less of the diet dry matter.

Condensed distillers solubles can be used as a conditioning agent, source of energy or source of protein. As a conditioning agent in the ration, CDS can be included at 5 to 10% of the diet dry matter. This level will help control dust and improve palatability of dry rations and increase energy and protein content of the diet. Although generally not included at levels above 10% of the diet dry matter, CDS are a good source of supplemental protein and energy in the diet.

Forage-Based Diets for Beef Cows

In forage-based diets for beef cows, distillers grains (wet or dry; with or without solubles) can be used as a source of supplemental protein and energy. The amount depends on the desired performance and nutrient content of the basal forage. In most cases, this would mean feeding up to 4 pounds of distillers grains per head per day on a DM basis.

Condensed distillers solubles can be used as a source of supplemental protein for beef cows fed low quality hay. Mixing CDS with chopped hay is the most effective way to deliver it to the cow herd. Producers may also consider pouring it on top of hay in the feeder or other delivery mechanisms. Condensed distillers solubles may also be mixed with other dietary ingredients or supplements and delivered to the cow herd in that manner. High variability in intake can be expected if CDS is not mixed with the forage or other dietary ingredients and delivered to the cattle in a mixed ration.

Creep Feeds

Dried distillers grains and DDGS can be used as an ingredient in creep feeds. The flavor, aroma and nutrient characteristics of DDGS make it an excellent addition to creep feeds. Best results are obtained when DDGS are included at no more than 50% of the creep feed.

Storing Wet and Dry Distillers Grains

Wet distillers grains and WDGS will mold rapidly (approximately seven days) during the summer. Cattle feeders should plan on feeding enough to use a truck-load on a weekly basis during the summer to minimize spoilage problems. During the colder winter months, spoilage develops at a much slower rate, extending the storage time. However, storage should not exceed three to four weeks unless plastic silage bags or other oxygen limiting structures are used to limit spoilage.

Wet distillers grains and WDGS can be stored in an oxygen-limiting environment such as plastic silage bags as a means of prolonging storage by limiting oxygen penetration. However, filling the bags can be difficult. If bags are packed too tightly, the bags can split as the WDG or WDGS settle. Care should be taken to not pack the bags too tightly. Holes should be patched or covered promptly to prevent spoilage. Wet distillers grains can be stored in bunker type silos and covered with plastic, however, some spoilage should be expected with this storage method.

Dried distillers grains and DDGS can be stored in conventional grain storage structures or in flat storage such as a quonset. Be sure to check the moisture content prior to storage to reduce spoilage or bridging problems. For long-term storage, the moisture level should be below 15%.

Material Handling Considerations for Liquid Coproducts

The use of liquid ingredients like CDS will require purchase of liquid feed handling equipment if such equipment is not already in place. Most liquid handling systems can be installed with a modest equipment investment. The tanks should be either housed indoors or buried underground to prevent freezing of the liquid materials. Because some settling and separation occurs with these liquids, a recirculating or agitation pump may be necessary to reduce settling if the CDS will be stored for longer periods of time. Condensed distillers solubles should be agitated prior to adding it to the feed ration or mixer.

Sources of Ethanol Coproducts in North Dakota

Sources of dried distillers grains suppliers and contact information.

Supplier	Marketing Contact
Alchem, Ltd. Grafton, N.D.	Commodity Specialist Company 1-800-769-1066
ADM Corn Processing Walhalla, N.D.	701-549-3931
Tri State Ethanol Rosholt, S.D	605-537-4585
Heartland Grain Fuels Aberdeen, S.D	605-226-0520
DENCO, LLC Morris, Minn	320-589-2931
Northern Lights Ethanol Big Stone City, S.D.	Dakota Commodities 1-888-327-8799
Glacial Lakes Energy Watertown, S.D.	605-882-8480

Other plants may be found in Minnesota and South Dakota, but transportation costs should be factored in before purchasing coproducts and shipping them great distances.

Summary

Coproducts from the ethanol industry are useful feed ingredients for beef cattle producers. Corn distillers grains are high in energy and protein and can be used in many different types of rations. Condensed distillers solubles can be used as a source of supplemental protein, a ration conditioner and a source of energy in beef cattle diets. However, because condensed distillers solubles are a liquid, they do require the purchase of liquid handling equipment. These coproducts can also vary in nutrient content and moisture level. Routine sampling and laboratory analysis is recommended and rations should be adjusted accordingly.

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Distillers Grains for Beef Cattle

Terry Klopfenstein

Distillers byproducts are excellent feed resources for feedlot cattle. Distillers byproducts are normally available for use in feedlot finishing diets in two forms, dried distillers and wet distillers byproducts (WDB). In general, there are two nutritional philosophies regarding their use in feedlot finishing diets. Distillers byproducts can be fed at 6 to 15% of the diet dry matter, serving primarily as a source of supplemental protein. When fed at higher levels (greater than 15% of the diet dry matter), the byproduct's primary role is a source of energy replacing corn grain. Other than dry matter content (wet distillers, 35-45%; dried distillers, 90-95%), the chemical composition of the two distillers byproducts is similar. Distillers byproducts contains 10-15% fat (oil), 40-45% neutral detergent fiber, 30-35% crude protein and 5% ash (NRC, 1996).

Dried distillers byproduct is routinely fed as a supplemental protein source, however, the drying process appears to reduce the energy value of the distillers byproduct. Ham et al. (1994) demonstrated a 9% improvement in feed efficiency when dried distillers byproduct replaced 40% of the dry-rolled corn in finishing diets (Table 1). However, this improvement was only 50% of that observed when wet distillers byproduct replaced a similar amount of dry-rolled corn. Drying cost significantly increases the commodity price for the distillers byproduct. The dried distillers byproduct is routinely priced relative to other supplemental protein sources like soybean meal. Therefore, when priced on an energy basis (relative to corn), the expected improvement in animal performance is not large enough to offset the increased ration cost associated with higher inclusion levels.

Wet distillers byproducts are commonly fed at higher levels in the diet to supply both protein and energy to the animal. There are numerous advantages to using wet distillers byproducts. For the dry-milling plant, the energy cost associated with drying the product can be significantly reduced or eliminated. This should allow for an overall increased energy yield for each bushel of corn processed. The major downside of using wet distillers byproducts is transportation costs associated with the movement of water.

Experiments evaluating the use of wet distillers byproducts in ruminant diets are available (DeHaan et al, 1983; Farlin,1983; Firkins et al.,1985; Ham et al.,1994; Fanning et al.,1999; Larson et al., 1993; Lodge et al.,1997; Trenkle,1997a; Trenkle,1997b). In the experiments with finishing cattle, the replacement of corn grain with wet distillers byproduct consistently improved feed efficiency. Larson et al. (1993) replaced dry-rolled corn with 5.2,12.6 or 40% (dry matter basis) wet distillers byproduct (Table 2). With the first two levels of byproduct (5.2 and 12.6), these researchers observed a 7% increase in feed efficiency above the basal dry-rolled corn diet. But, when the inclusion level was increased to 40% of the diet dry matter, the improvement in feed efficiency was 20% above the dry-rolled corn diet. In other published experiments (Ham et al., 1994; Fanning et al., 1999; Lodge et al., 1997) the inclusion level of the wet distillers byproduct has been 30 to 40% of the diet dry matter. These experiments consistently suggest a 15 to 25% improvement in feed efficiency when 30 to 40% of the corn gain is replaced with wet distillers byproduct.

Distillers grains made from sorghum and corn were compared at 30% of the diet dry matter. Statistically the byproducts had similar feeding values (Table 3) although the corn derived grains were numerically, slightly better.

Eleven experiments were summarized where WDB was compared to corn as an energy source for finishing cattle (Table 4). The WDB replaced 12.6 to 50% of the diet (corn). The data were summarized into three situations. First is the control diet based on dry rolled corn. Second is when WDB replaced corn at a low level in the diet (12.6 to 28%). The third situation is where WDB replaced corn in the diet at 30 to 50% of diet dry matter.

At the low level (ave. 17.4%) of WDB feeding, the energy value was 152% that of corn. At the high level of feeding, the value decreased to 136% the value of corn. We can then calculate the value of the WDB as 124% the value of corn when fed between 17.4 and 40% of the diet.

We believe there are very good explanations for the change in relative feeding values as WDB increases in the diet. We believe the first increments fed (up to 17.4%), supply nutrients such as protein that may be of value to the cattle but more importantly reduce the acidosis that occurs in the control diet. The WDB contains protein and fat which supply energy to the animal but it does not contain the starch that leads to acidosis. Further, the fiber (hull) in the WDB is highly digestible but adds fiber to the diet and reduces acidosis. So the very high value of the WDB (152%) at low level feeding is probably due to factors other than the strict energy value of the nutrients contained therein.

The value when fed above 17.4% of the diet is probably due to the high fat content of the WDB and the high content of bypass protein. Fat has about three times the energy value of starch for cattle and bypass protein has about 30% more energy than starch. The value from feeding trials was determined to be 124% the value of corn. By calculating the theoretical energy value based on the bypass protein and fat contents, we estimate the energy value of WDB to be 120% the value of corn. This calculation gives confidence in the value obtained from feeding trials.

Typical feedlot diets contain about 85% corn. The starch in the corn is the energy source used by the cattle. However, the starch is rapidly fermented by the rumen microorganisms to organic acids. The overproduction of the organic acids causes acidosis followed by reduced feed intake and reduced gains (Stock and Britton, 1993; Stock et al., 1995). Distillers byproducts have essentially all of the starch removed leaving protein, highly digestible fiber and fat. The feeding of the byproducts appears to reduce acidosis and enhances feed efficiency.

The previous research indicates that wet corn byproducts (distillers grains and thin stillage) are higher in net energy than corn grain; however, wet corn gluten feed (WCGF) is similar in net energy to corn. Potential differences between wet distillers byproducts and WCGF include lipid content, escape protein level, and NDF level.

A finishing trial using 60 individually fed yearling crossbred steers (600 lb) was conducted. Treatments consisted of a dry rolled corn, WCGF, wet distillers byproducts composite (COMP2), (WCGF, corn gluten meal, tallow), COMP2 minus tallow (-FAT) and COMP2 minus corn gluten meal (-CGM). The tallow and corn gluten meal were replaced with wet corn gluten feed. The COMP2 was formulated (DM basis) to contain 12.5% degradable protein, 12.5% undegradable protein, 13.1 % lipid, and 32.7% NDF and consisted of 65.8% WCGF, 26.3 % CGM, and 7.9% tallow (DM basis). All diets contained (DM basis) 79.1 % dry rolled corn or dry rolled corn plus 40% corn byproducts, 5% corn silage, 5% alfalfa, 5.9% molasses based supplement, and 5% dry supplement.

Steers consuming the COMP2, -CGM, and dry rolled corn diets were more efficient (P<.10) than the steers fed dry rolled corn or WCGF diets (Table 4). No difference in ADG was observed among treatments (P>.10). Steers fed the COMP2 diet consumed less (P<.10) feed than steers fed the dry rolled corn diet with the steers fed WCGF, -FAT, and -CGM being intermediate (P>.10) to these treatments.

A composite of feeds can be formulated that improves efficiency of gain compared with WCGF. However, it is not clear what level of fat, fiber, or escape protein or how the interactions of these ingredients may contribute to the increases in feeding value observed with distillers byproducts. These results indicate that the lipid fraction of the distillers byproducts may be responsible for the largest increase in efficiency.

There are at least three factors involved in the higher feeding value for distillers byproducts (protein, energy, acidosis). Based on the limited data available regarding the level of wet distillers byproduct in the diet, the economic value of the byproduct varies as the level fed in the diet changes. Also, as the level fed increases, more is fed per animal per day and more total byproduct would be fed. The precise relationship between level of byproduct in the diet and both the feeding value and economic value remains elusive.

Distillers Grains for Stocker Cattle, Heifers and Cows

Beef calves from weaning until they enter feedlots, developing heifers and beef cows are fed primarily forage diets. Especially in the winter, forages are low in protein and phosphorus and need to be supplemented. Further, the protein in forages is highly degraded in the rumen and the cattle should be supplemented with undegraded (bypass) protein to meet metabolizable protein requirements. Distillers grains (wet or dry) is an excellent source of undegraded protein and phosphorus. The values obtained from feeding trials for undegraded protein are shown in Table 5. Wet grains were compared to dry grains and the value of the protein was similar (Table 6). This suggests that the high escape protein value of distillers grains is due to the innate characteristics of the protein and not to drying or moisture control.

Stocker calves, developing heifers and cows may need energy supplement in addition to supplemental protein and phosphorus. It is advantageous if the same commodity can be used for supplemental energy as well as protein. We previously stated that distillers grains should have 120% the energy value of corn grain. For example, corn at $2/bu is $79/ton (90% dry matter). That means dried distillers grains would be worth at least $95/ton as an energy source. Additional advantages for distillers grains are that it contains very little starch and therefore should not depress fiber digestion.

The value of distillers grains as a protein supplement is illustrated in Table 7. We have shown the formulation and cost of a soybean meal based supplement and a distillers grains based supplement. They should have equal feeding value but the distillers grains supplement is less expensive because of the high escape value of the protein. Less expensive midds and urea can then be used in the supplement. This illustrates just how economical distillers grains can be as a supplement to stockers, heifers and cows.

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Table 1. Energy Value of Wet vs Dry Grains

	Control	Wet	Low[a]	Medium[a]	High[a]
Daily feed, lb	24.2 b[bc]	23.56[b]	25.3[c]	25.0[a]	25.9[a]
Daily gain, lb	3.23[b]	3.71[c]	3.66[c]	3.71[c]	3.76[c]
Feed/gain	7.69[b]	6.33[c]	6.94[d]	6.76[d]	6.90[d]
Improvement:					
Diet	--	21.5	--	11.9 (ave.)	
Distillers vs corn	--	53.8	--	29.8	

[a]Level of ADIN, 9.7, 17.5 and 28.8%.

[b,c,d]Means in same row with different superscripts differ ($P<.05$).

Table 2. Effect of Wet Distillers Byproduct Level on Finishing Performance of Yearlings and Calves

Item	Byproduct level, % of diet DM[a]			
	0	5.2	12.6	40.0
Daily feed, lb				
Yearlings[b]	25.21	24.64	24.05	21.30
CalveS[b]	18.52	19.23	18.55	17.40
Daily gain, lb				
Yearlings[c]	3.61	3.76	3.85	3.85
Calves[b]	2.86	3.06	3.08	3.21
Feed/gain				
Yearlings[e]	6.94	6.62	6.33	5.78
Calves[b]	6.45	6.33	6.10	5.65

[a]Wet grains:thin stillage (fed ratio), yearlings = 1.67:1; calves = 1.81:1, DM basis.
[b]Byproduct level, linear (P<.O1).
[c]Byproduct level, linear (P<.10); quadratic (P<.10).
[d]Feed/gain analyzed as gain/feed. Feed/gain is reciprocal of gain/feed.
[e]Byproduct level, linear (P<.10).

Table 3. Corn vs Sorghum Distillers Byproducts

Item	Diets[a]		
	DRC	CORN	SORG
Initial weight, lb	791	790	792
DMI, lb/day	23.5	22.9	25.4
ADG, lb	3.64	3.95	4.11
Feed/gain	6.48	5.81	5.97
Yield grade	2.32	2.65	2.56
Choice	95	70	74

[a]DRC = dry-rolled corn (control), CORN = corn distillers grains, SORG = sorghum distillers grains.

Table 4. Influence of Level in Diet on Value of Wet Grains Plus Solubles in Feedlot Diets

Experiment	WDB level in diet dry matter 0	12.6 - 28%	30 - 50%
Trenkle, 1997a	.154a	.183 (20)a 194%[c]	.176 (40) 137%
Trenkle, 1997a	.154		.176 (40) 136%
Trenkle, 1997b	.164	.207 (16) 126%	.168 (40) 102%
Trenkle, 1997b	.164	.171 (28) 114%	
Firkins et al., 1985	.155	.156 (25) 101%	.171 (50) 121%
Larson et al., 1993	.144	.158 (12.6) 177%	.173 (40) 150%
Larson et al., 1993	.155	.164 (12.6) 164%	.177 (40) 135%
Ham et al., 1994	.133		.158 (40) 147%
Fanning et al., 1999	.154		.172 (30) 147%
Means		152% (17.4)	136% (40)
Value 17.4 to 40			124%

[a]Feed efficiency

[b]Level in diet dry matter.

[c]Value relative to corn.

Table 5. Escape Protein Values

Source	% protein escape
Soybean meal	30
Wet distillers grains	60-70
Dried distillers grains	60-70
Distillers solubles	30

Table 6. Wet and Dry Grains for Calves

Supplement	ADG	Protein efficency[a]	ADIN[b]
Urea	1.00	--	--
WG	1.46	2.6	--
DDGS	1.42	2.0	9.7
DDGS	1.47	1.8	17.5
DDGS	1.54	2.5	28.8

[a]Pounds gain/lb supplemental protein.

[b]Acid detergent insoluble nitrogen, measure of amount of heating.

Table 7. Value of Distillers Grains - 40% Supplement

	SBM	DDG
SBM -	78.7%	--
DG	-	60%
Midds	20.3	32.8
Urea	---	6.2
Minerals	1.0	1.0
Ingredient cost	$153	$95

Prices: SBM, $161; DDG, $95; Midds, $61; Urea, $280 (corn $75).