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Ethanol Co-Product Use in U.S. Cattle Feeding

Lessons Learned and Considerations

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Contents

Approved by USDA's World Agricultural Outlook Board

Abstract

The byproducts of making ethanol, sweeteners, syrups, and oils used to be considered less valuable than the primary products. But the increased livestock-feed market for such byproducts in the past few years has switched that perception to one of the ethanol industry making grain-based "co-products" that have market value separate from the primary products. Co-products such as dried distiller's grains, corn gluten feed, corn gluten meal, corn oil, solubles, and brewer's grains have become economically viable components, along with traditional ingredients (such as corn, soybean meal, and urea), in feed rations. The co-products have limitations, such as variable moisture content, product availability, nutrient excesses or deficiencies, and nutrient variability. These limitations affect how they must be handled and stored and how much they cost feed buyers. Dried distiller's grains are more amenable to pelleting and other bulk-handling methods than other co-products, which gives them an advantage in international markets.

Keywords: Cattle feeding, corn gluten feed, distiller's grains, dry-mill, energy, ethanol co-products, protein, wet-mill

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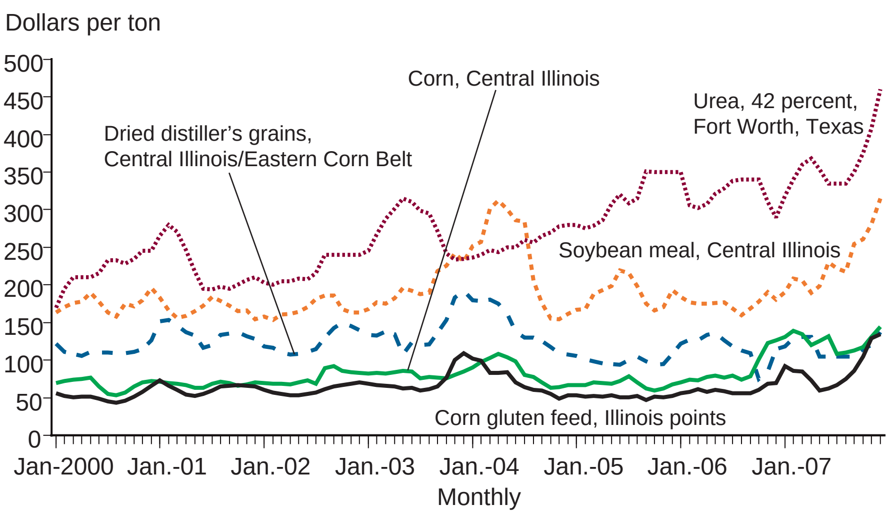
Introduction

The expansion of the ethanol industry led to increased demand for corn and an increased supply of co-products from the ethanol production processes. Concurrently, high global commodity prices, attributed to increased global demand for food and feed, poor weather conditions in some major crop-producing areas, and the worldwide expansion of biofuel production, have detrimentally impacted the livestock feeding industry (Trostle, 2008). Co-products from ethanol, sweeteners, syrup, and grain-based oil production have been used as livestock feed for many years, but only recently have become a more widespread economic alternative for coping with high prices for feedstuffs such as corn, soybean meal, and urea (fig. 1). Dairy cattle operators have the most experience of agricultural producers who use co-products. Dairy operators, surveyed by the National Agricultural Statistics Service (NASS) in 2007 indicated that, on average, they had fed co-products 9.2 years (USDA, NASS, 2007). Cattle feeders and cow-calf operators indicated they have used them, on average, for 5.1 years and 4.6 years, respectively. Co-product feeding is relatively new for hog operations, with survey respondents indicating they had used co-products 2.7 years on average.

Ethanol plants increasingly compete with livestock feeders for corn. However, ethanol production also results in co-products that can be substituted as sources of energy and protein in livestock feeding (table 1). The removal of starch through ethanol and sweetener production reduces the quantity of the feedstuff available in a bushel of corn or other grain. For example, a bushel of corn (56 pounds) that yields 2.6 to 2.8 gallons of ethanol reduces in the dry-mill process to about 17.5 pounds of dried distiller's grains with solubles containing 10-percent moisture. The same bushel in the wet-mill process reduces to 11-13 pounds of corn gluten feed, 2.6 pounds of corn gluten meal, and 1.6 pounds of corn oil (Biomass Research and Development Board, 2008; Westcott, 2007; Sevcik, 2006; Wisner, 2007; Shapouri, 2009).

Figure 1

U.S. prices for selected feedstuffs



Source: USDA, ERS, Feed Grains Database, www.ers.usda.gov/Data/FeedGrains/.

Co-products have been supplied historically from industrial uses of corn and other grains, which have grown in recent years with increased ethanol production (table 2). While some corn usage for feed has been diverted to ethanol production, reducing feed uses of corn and other grains, the bulk of increased ethanol-driven corn usage has come from increased corn acreage, often a result of reallocating crop acreages. As a result, the total supply of grain-based feeds is expanding (fig. 2). Thus, the increased availability of co-products has actually increased feed supplies (table 3). This has led to expanded interest in feeding co-products and periods of favorable relative prices have increased their substitution for corn.

Co-products made from grain-starch-based and corn-oil products include corn gluten feed (CGF), corn gluten meal (CGM), wet distiller's grains with solubles[1] (WDGS), dried distiller's grains without solubles (DDG), dried distiller's grains with solubles (DDGS), and solubles alone (condensed distiller's solubles (CDS)).

[1]Solubles are the liquid portion, or thin stillage, removed from the mash (a mixture of grain, water, and other ingredients) during the process of producing ethanol. Solubles are essentially a byproduct stream, but, because they do contain some nutrients, the solubles can be included in the distiller's grains co-products.

Table 1
Nutrient profiles of selected feedstuffs

	Dry matter	Crude protein	Total digestible nutrients	Lysine	Methionine	Sulfur
			Percent			
Corn	87	7.5	80	.24	.18	.08
Soybean meal	88	47.8	79	.71	.70	.43
Dried distiller's grains with solubles	92	27	82	.80	.51	.30
Wet distiller's grains with solubles	34.9	31	91			
Corn gluten feed	88	21	75	.60	.50	.16

Source: *Feedstuffs: 2009 Reference Issue and Buyers' Guide*, 2008.

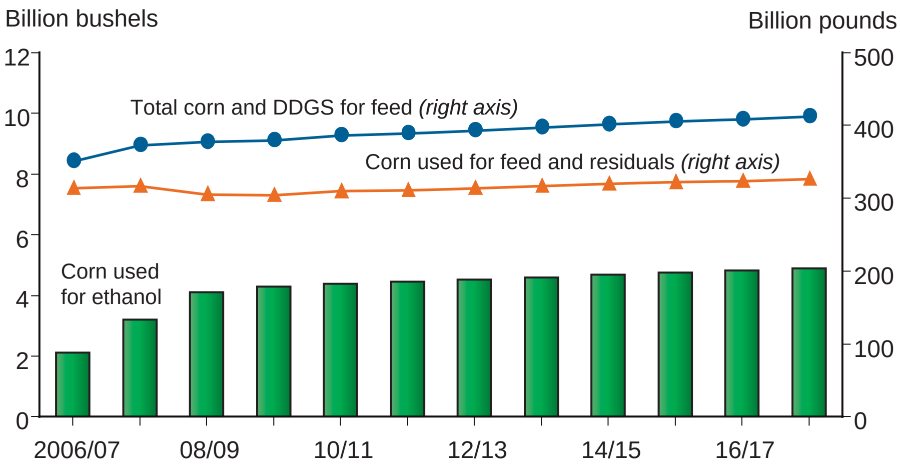
Table 2
U.S. ethanol production

Year	*Million gallons*
1990	748
1991	866
1992	1,083
1993	1,154
1994	1,289
1995	1,358
1996	973
1997	1,288
1998	1,405
1999	1,465
2000	1,622
2001	1,765
2002	2,140
2003	2,804
2004	3,402
2005	3,904
2006	4,884
2007	6,521
2008	9,237

Source: U.S. Department of Energy, Energy Information Administration. http://www.tonto.eia.doe.gov/dnav/pet/pet_pnp_oxy_dc_nus_mbbl_m.htm/.

Figure 2

Total feed projections



Note: DDGS = Dried distiller's grains with solubles.

Source: *USDA Agricultural Projections to 2018*, www.ers.usda.gov/publications/oce091/.

Table 3

Corn provides inputs into both feed and ethanol production

Market year[1]	Production	Food, seed, and industrial use, minus fuel production	Fuel ethanol production	Feed and residual use	Total domestic use
			Million bushels		
2001	9,502.58	1,340.42	705.95	5,864.27	7,910.63
2002	8,966.79	1,344.71	995.5	5,562.88	7,903.10
2003	10,087.29	1,369.56	1,167.55	5,793.02	8,330.13
2004	11,805.58	1,363.79	1,323.21	6,155.47	8,842.47
2005	11,112.19	1,378.39	1,603.32	6,152.28	9,133.99
2006	10,531.12	1,370.75	2,119.50	5,591.00	9,081.25
2007	13,037.88	1,337.29	3,026.13	5,938.13	10,301.55
2008	12,101.24	1,300.00[2]	3,600.00[2]	5,300.00[2]	10,200.00[2]

[1]Marketing year is September to August.

[2]Projected.

Source: USDA, ERS, Feed Grains Database, www.ers.usda.gov/Data/FeedGrains/.

Ethanol, Sweetener, and Starch Production Process

The co-products that are the focus of this report are created in the production processes of wet-mill and dry-mill corn plants. Corn and, in some cases, other grains are used as feedstocks in these mills to make primarily starch-related products (ethanol, sweeteners, and syrups) as well as oils. The wet- and dry-milling processes produce primary products and co-products with different characteristics.

Wet-mill plants use an intensive process to separate different parts of a corn kernel to produce syrups, ethanol, corn-starch-based plastics, oil, and other products. In the steeping process, corn kernels are softened in fresh water before being separated into bran, starch, protein, germ, and soluble components. Each component then goes through its own manufacturing process to create additional products. For example, the starch components are used to make ethanol. Bran and the fibrous remnants from the steeping process, distiller's solubles, are combined to make corn gluten feed.

Wet-mill plants are not as common as dry-mill plants, being more capital-intensive and requiring more investment per bushel of corn. However, wet-mill plants' revenue streams are more diversified because they create a variety of high-value products from a single kernel. There have been no new wet-mill plants built in the United States in the past 10 years, but a new one is being built in Iowa and production capacities of existing plants are expanding (Lawrence, 2009).

Dry-mill plants, designed to produce one product, corn-based-ethanol, have been at the center of the expansion of ethanol production in the United States over the past few years. The dry-mill process is less complex than the wet-mill process. Dry milling cooks and ferments ground corn, using enzymes and yeast to produce ethanol and carbon dioxide. Once the starch is converted to an alcohol, the leftover stillage is turned into distiller's grains. Dry-mill plants are generally smaller and require less capital investment per bushel of corn than wet-mill plants. However, some dry-mill plants are extracting more co-products through investment in fractionation and separation technologies (Lawrence, 2009). Although most are located in the Corn Belt (Illinois, Iowa, Minnesota, Nebraska, and South Dakota), plants are also located, planned, or under construction in other States (California, Georgia, New York, Texas, and Washington).

The value that co-products add to profit margins has become critical in maintaining processing plants' economic viability. When ethanol prices and profit margins for ethanol production were high, co-products were not as important as a source of revenue for ethanol plants. More recently, as ethanol prices have fallen and co-product demand has risen from livestock producers, co-product prices have been boosted to levels that, at times, exceeded the value of corn for feeding.

Experience and Education Enhance Nutrient Management

Co-products possess generally attractive nutrient profiles that render them useful as ingredients in feed rations for livestock, poultry, pets, and other animals (see table 1). Energy contents are on a par with feed grains, and co-product protein content usually falls between the lower protein content of grains and the higher content of oilseed meals. Based on USDA's baseline projections, co-products could increase the total supply of energy and protein available for livestock feeding (figs. 3 and 4). Among the livestock species, animals with a rumen compartment in their stomachs are best able to utilize co-products in feed rations.[2] According to a National Agricultural Statistics Service (NASS) report, feeding co-products to livestock is most common in dairy and cattle feeding operations and less common in hog and cow-calf operations (USDA, NASS, 2007). However, the report also shows that among producers not using co-products, those feeding cattle and hogs are most likely to consider using co-products, presumably if cost-effective opportunities exist.

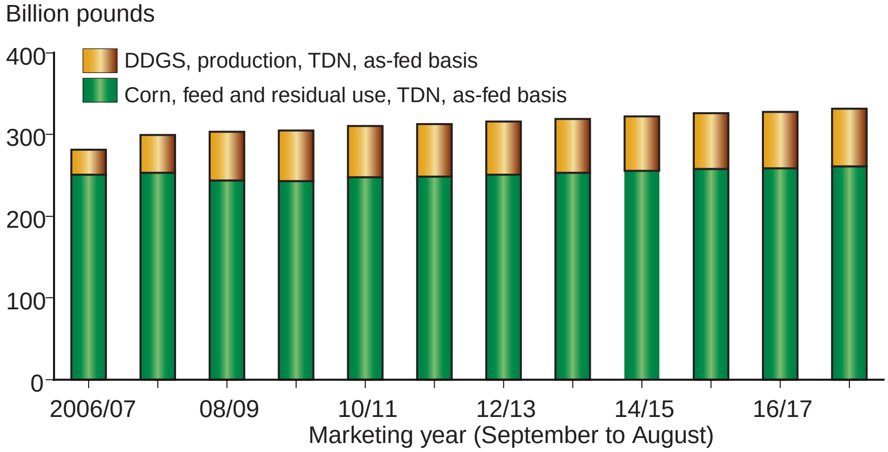
There are additional co-product characteristics that support inclusion in livestock rations. Cow-calf operators and cattle feeders tend to use co-products when they provide a high energy value for the cost, compared with traditional energy sources like corn or other grains. Dairy and hog operations, on the other hand, value co-products for their protein as well as energy, and use them as cost-effective substitutes for traditional grains and proteins in feed rations.

Nutrients present in corn or other feed grains used to produce ethanol and other starch-based products are concentrated during the milling process by a factor of about 3. For some nutrients, like lysine and methionine, the resulting concentration is a plus, as those amino acids are often at insufficient levels in most common feedstuffs and must be supplemented in livestock rations (Schingoethe, 2007). Co-products can reduce the need for supplements, potentially reducing the overall feed costs.

[2]A ruminant is an animal with a rumen compartment in its stomach. Examples include cattle, sheep, goats, deer, elk, and bison. Unlike animals with a single compartmented stomach (monogastric), ruminants are able to convert cellulose in its various forms into starches and sugars, which can then be metabolized.

Figure 3

Corn feed use, DDGS production increase feed energy potential (TDNs)

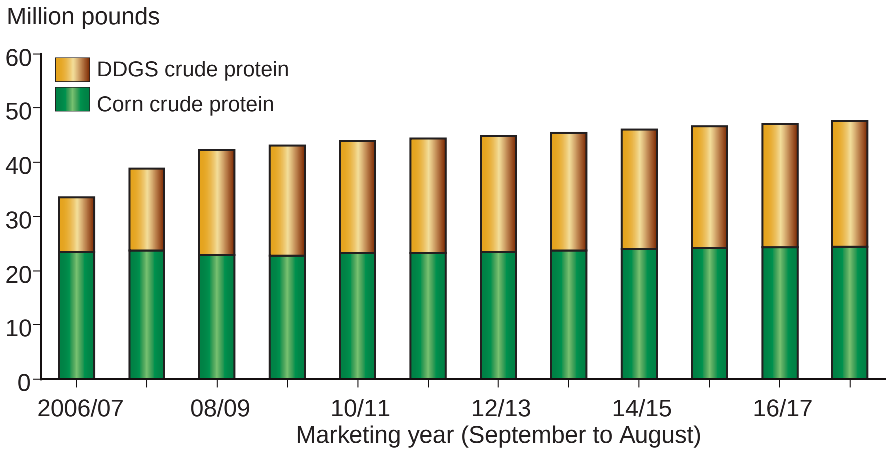


Note: TDN = Total digestible nutrients; DDGS = Dried distiller's grains with solubles.

Source: *USDA Agricultural Projections to 2018*, www.ers.usda.gov/publications/oce091/.

Figure 4

Crude protein production projections



Note: DDGS = Dried distiller's grains with solubles.

Source: *USDA Agricultural Projections to 2018*, www.ers.usda.gov/publications/oce091/.

However, with other nutrients, the concentration produced during ethanol production can be a negative. Some nutrients, like sulfur, can reach levels toxic to livestock, and means of offsetting the excess nutrient must be utilized. Sulfur can reach excessive levels in wet or dry distillers' grains with solubles when too much sulfuric acid is used in the cleaning process, or if the water used has a naturally high sulfur content (Erickson et al., 2007; Schingoethe, 2007). High-sulfur water issues can be exacerbated if water on the livestock operation contains sulfur.

For some nutrients, the concentration achieved during milling can be positive or negative, depending on circumstances. Phosphorus, for example, is concentrated as a readily available, highly digestive form, which can reach significant levels in manure. This is a positive if the manure is then spread on land deficient in phosphorus, but can be a negative if it contributes to excessive phosphorus in the soil or contributes to surface water pollution (Schingoethe, 2007).

Ruminants fed rations high in grain content can fall victim to acidosis, a condition in which excessive organic acids are produced in the rumen as a result of fermentation of the starch in grains. Metabolizing these organic acids can damage the liver, which results in liver condemnations and reduces packer revenues from edible offal. Increasing the amount of fiber in rations with roughages can reduce the incidence of acidosis, but at the expense of reduced per-unit energy and protein. However, with little or no loss in energy and a gain in protein content, fiber content in the co-product condensed distiller's solubles is two times greater than the fiber in corn, and corn gluten feed (CGF) has five times the fiber that corn does. Fiber content limits the usefulness of co-products such as CGF in hog and poultry rations. Combinations of co-products in highly intensive cattle feeding rations can reduce the incidence of acidosis (Schingoethe, 2007).

Storage, Moisture, and Prices of Other Feed Ingredients Affect Economic Viability

The price of competing feeds dictates how economical it is to feed co-products. DDG, CGF, and other co-products were used for livestock feed before ethanol production began rapidly increasing in 2003, but the price ratio of co-product to corn was relatively high. This high price ratio was partly due to foreign demand for DDG. Both corn and DDG prices declined 17 percent from 2003 to 2005[3] (USDA, ERS, 2009). During this short period of price declines for DDG, byproducts were viewed as slowing the ethanol production process until they could be removed (Rendleman and Shapouri, 2007).

[3]Calendar-year basis

Growing supplies of co-products and high corn prices opened up a larger market for co-products as livestock feed and led to the current view of their value. Until late in 2008, both corn and DDG prices had increased to record or near-record levels from their respective lows in 2005 and 2004. In 2003, the DDG-to-corn price ratio was well above 1. At times during 2007 and 2008, the ratio declined to levels of about .85, a level at which it is competitive to use DDG instead of corn for feeding to hogs and poultry.

CGF was the most common co-product fed to cattle on both cow-calf operations and feedlots (USDA, NASS, 2007). CGF used in cattle feeding operations had a higher moisture content (52 percent compared to 26 percent) and was less than half the price ($44.22 per ton versus $101.29) compared to CGF used by cow-calf operators. This price difference mostly reflects costs of drying co-products for pasture feeding. Additionally, 36 percent of cattle feeders that fed co-products to their livestock used WDGS. These WDGS have even more moisture than corn gluten feed, ranging from 57 percent (over 40 percent solids) to 60 percent (25-40 percent solids). At $28.28 (25-40 percent solids) to $31.61 (over 40 percent solids) per ton, these were also the cheapest form of co-products (USDA, NASS, 2007).

Some of the differences between these prices and characteristics can be explained by logistics and geographic location. Where ethanol plants and larger cattle feedlots are in close proximity, co-product inclusion in feed rations is more widely practiced. For example, in a Nebraska study, 59 percent of Nebraska cattle feeding operations[4] included co-products in feed rations (Waterbury et al., 2009). At the national level, 36 percent of feedlots fed co-products (USDA, NASS, 2007).

[4]These feedlots had an average one-time capacity of 5,760 head and accounting for 91 percent of cattle represented in the survey.

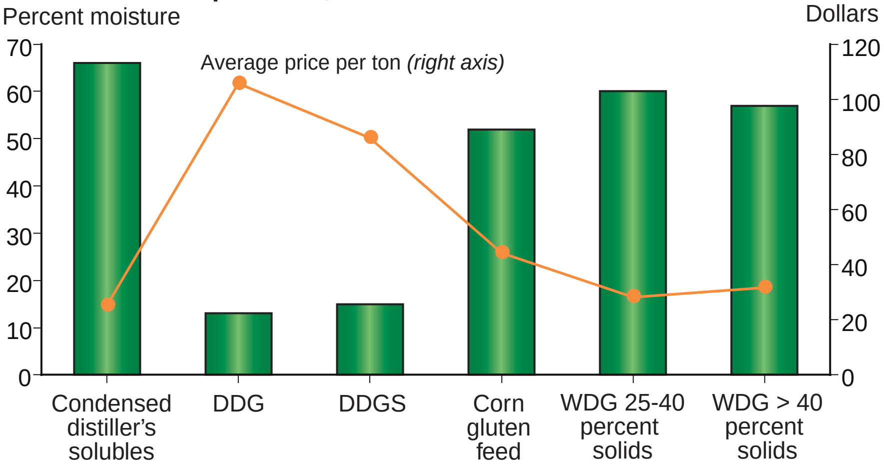
Cattle feeders also use co-products other than distillers' grains and sometimes rely on co-product combinations. In some cases, the combinations can result in higher feeding values for traditionally processed feed ingredients. For example, high-moisture corn was found to have greater value when fed with wet CGF to beef cattle (Erickson et al., 2007). Some combinations being used include CGF with corn, corn oil and roughage, including soybean straw, and Cargill's Sweet Bran.[5]

[5]Sweet Bran is a registered trademark of Cargill, Incorporated. It is a dairy feed made from ingredients of the wet corn milling process.

The cost of drying various co-products is at least partially reflected in various price differentials (fig. 5). According to NASS, DDG without solubles were the co-product choice of most dairies (45 percent) and hog producers (44 percent). Feed of this type was characterized by low moisture content—12 and 10 percent, respectively—and was relatively more expensive than other

Figure 5

High-moisture co-products cost cattle feeders less than low-moisture co-products, 2007



Note: DDG = dried distiller's grains; DDGS = dried distiller's grains with solubles; WDG = wet distiller's grains.

Source: USDA, National Agricultural Statistics Service, http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1756/.

co-products, at average 2006 prices of $118.47 per ton for dairy cattle and $109.49 per ton for hogs (USDA, NASS, 2007). A large proportion of hog producers (37 percent), particularly larger producers, also used DDG with solubles (DDGS). Solubles can add some energy via their extra fat content and they contain a higher share of phosphorus.

In conjunction with prices, the economic viability in distributing and storing co-products will play a large role in determining how extensively they are used. Advancements in logistics and efficiency improvements in the supply chain will be major factors that will affect the demand and price of co-products in the future. Technological improvements that result in more consistent products would lower the cost and increase the demand for these feedstuffs.

International demand for U.S. co-products will also affect domestic supplies and markets. In the 2007 marketing year (September 2007 to August 2008), foreign markets bought about 19 percent of U.S. production. U.S. exports of DDG and DDGS have expanded exponentially to livestock-producing countries, especially countries with relatively high prices for corn and soybean meal. The U.S. Grains Council estimated that the dollar value of U.S. exports of DDG could reach $1 billion in 2008, up from only $76 million in 2002/03, and could reach $3.5 billion for an estimated 14 million metric tons by 2015 (Keefe, 2008). Mexico, expected to import over a million metric tons of U.S. DDG in 2008, is the largest foreign market, followed by Canada, Turkey, Taiwan, South Korea, and Japan (Keefe, 2008).

Improvements in Storage and Transportation Are Keys to Future Use

Co-products have a number of physical characteristics that present logistical issues for livestock producers using them in feed rations. These characteristics, as well as some chemical characteristics, make transporting, handling, feeding, and storing co-products challenging.

The biggest obstacle to providing co-products to livestock feeders is transporting the feeds from the processing plant to the livestock feeding operation. Depending on the co-product's final processed form, varying degrees of difficulty occur in loading, shipping, and unloading. Moisture in the co-product can cause spoiling and depreciate nutritional content, particularly in the summer when temperatures are higher. The shelf life of high-moisture feeds can, therefore, be relatively short.

High moisture content also makes the co-product more difficult to handle for shippers. Shipping a high-moisture feed adds to the total weight of the shipment, and product consistency can cause the co-product to stick to the containers, causing difficulties in the unloading process. Generally, the lower the moisture content, the easier it is to transport co-products.

However, removing moisture from co-products requires large, capital-intensive dryers and increases energy costs. In addition to the cost of drying, exposing co-products to high temperatures increases the risk of scorching, which can reduce the nutritional content and the overall value of the feed. In some cases, livestock producers feeding low-moisture co-products find animals exhibit lower feed efficiency, which the producers remedy by putting water back into the feed. Drying costs account for most of the price differential between co-products that differ only in moisture content.

Typically, U.S. livestock operations where co-products are used are larger operations (USDA, NASS, 2007). Such operations can use larger quantities of co-products on a regular basis, providing ethanol plants with a continuous and consistent market for their co-product production. Cattle feeding operations where co-products were used averaged 76 percent larger than all cattle operations (1,276 head vs. 725 head) (USDA, NASS, 2007). Hog operations using co-product feed were over three times as large as average operations (10,957 head vs. 3,256 head). One reason for this size differential is that co-products need to be transported from the ethanol production facility as soon as possible to make room for the next batch of co-products, in order to maintain peak ethanol production. Livestock feeding operations that can make use of full truckloads of co-products are more easily able to work with ethanol plants to obtain co-products on a regular basis at attractive prices or perhaps even contract for delivery.

Based on 2007 NASS survey results, larger cattle feeders near plants may have been the best customer for co-products because (USDA, NASS, 2007):

1. Cattle feeders report prices at a discount compared to dairy, hog, and cow-calf operations.
2. Cattle feeders report using co-products with the highest moisture content.
3. Cattle feeders report that they receive the fewest services from co-product suppliers, compared with other cattle operations, and they are twice as likely to order their feed directly from a processing plant.

Erickson et al. (2007) observed that returns per head decrease with the distance needed to ship a given proportion of Cargill's Sweet Bran used in cattle feeding rations, especially if the distances were at least 100 miles from an ethanol plant. Similar results were observed in another Nebraska study (Waterbury et al., 2009). These findings may also reflect the ability of cattle to grow to slaughter size more efficiently on feed with WDGS compared with feed efficiency when cattle are fed DDGS, as well as the fact that co-products are less expensive prior to incurring drying costs.

Since the movement of co-products offsite facilitates ethanol production, ethanol manufacturing plants are anxious to market and transport the co-products as quickly as possible. The most economical situation for ethanol producers is to be able to ship large amounts of high-moisture co-products for short distances, thus, avoiding drying costs as well as maintaining nutritional content and limiting spoilage. Livestock operations situated within 100 miles of ethanol plants therefore have an advantage in being able to obtain and use co-products efficiently.

Transportation technologies are constantly being introduced and improved. For example, unit trains (such as 90- or 110-car trains dedicated to a single type of traffic), are being used to ship co-products to specific locations. Some milling/processing plants have built specialized rail track loops and unloading facilities to move their co-products. Some are able to unload special railroad cars without decoupling them, and rotate the entire car upside down, to dump co-products into pits from which they can be redistributed or mixed with other feed ingredients and fed to livestock.

Most U.S. livestock producers buy their co-products on the spot market and prefer not to buy under contracts (USDA, NASS, 2007). Contracting for co-products may result in a more reliable supply source. In a study focusing on Nebraska cattle feeders, who are generally close to ethanol plants, most co-product was sold in 2007 on a fixed-price, annual contract basis (Waterbury et al., 2009). However, in 2008, the absence of contracts between ethanol producers and livestock operations may have been motivated by ethanol plants (Mark, 2009). Cost may not be the only reason producers would contract their co-products; consistency and quality of the co-products are also concerns.

Co-products' quality and content can vary as processors make adjustments in order to optimize production. Because the feed is a byproduct of the processing plant, the nutrient contents of the feed may vary, based on a number of factors in the production process of primary starch related products and oils. However, as the profit margins from ethanol production decline, ethanol producers have made more efforts recently to manufacture feed co-products that are consistent in quality and content, which can sell at a premium.

Education among livestock operators about how to use co-products as animal feed appears to be a determinant in the widespread use of co-products. Although most respondents in a NASS survey stated that lack of availability of co-products was the primary reason why they did not feed co-products to their animals, 5 percent of producers in every livestock category cited lack of knowledge as the primary reason (USDA, NASS, 2007). There is potential for more co-product use if U.S. livestock operators become more knowledgeable about how best to manage ethanol co-products as animal feed.

Considerations for the Future

The use of co-products in feed for U.S. dairy, meat, and poultry production will be affected by a number of competing factors. The development and growth of the ethanol industry will affect the availability of corn for feed, increasing competition in the corn market. As the ethanol industry grows, there will be a corresponding increase in co-products available to substitute for corn in animal feed.

Ethanol production increased 232 percent between 2003 and 2007, rising from 2.8 billion gallons to 6.5 billion gallons (table 2). The Energy Independence and Security Act of 2007 established the Renewable Fuel Standard (RFS) which mandates the use of biofuels at 11.1 billion gallons in 2009 rising to 36 billion gallons in 2022. Some of the 36 billion gallons is to come from cellulosic ethanol and other advanced biofuels. The maximum amount of corn-based ethanol that can be used to meet the RFS increases from 9 billion gallons in 2008, to 15 billion gallons in 2015. If all 15 billion gallons were produced from dry-milling corn, as much as 98 billion pounds of DDG could be produced from 5.6 billion bushels of corn.

Co-products add to the options available to informed livestock producers to develop the best feeding strategies possible. Increased education of and outreach toward livestock and poultry producers about how best to use co-products as animal feed will influence how operators adapt the new co-products to future feed rations. New information on co-products' nutritional values, distribution possibilities, and other aspects will be disseminated to the livestock industry through extension offices and publicly available research, among other forms of communication.

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