Updated Trends in U.S. Wet and Dry Corn Milling Production

Daniel O'Brien, Extension Agricultural Economists

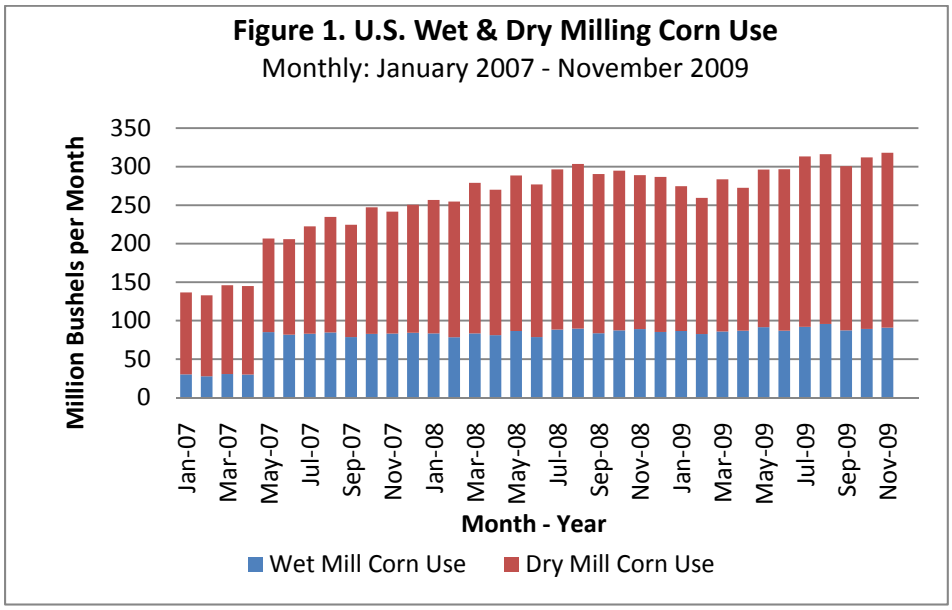
Kansas State University

The purpose of this article is to examine the production of feed byproducts originating from wet and dry corn milling processes in the United States. Two distinct processes for processing corn are common in the U.S., i.e., wet-milling and dry-milling. Ethanol is the primary product of the U.S. dry milling process, and also is also one of the products produced via wet milling processes.

This article is an updated version of a February 2009 article on U.S. wet and dry corn milling industry grain use and byproduct production. It utilizes monthly information presented from U.S. Census Bureau Division of Manufacturing, Mining and Construction Statistics - M311J - Fats and Oils, Oilseed Crushing Report up through the latest reported information for November 2009. It also references and builds upon information presented by Kelly S. Davis at the 2001 Minnesota Nutrition Conference of the Minnesota Corn Growers on "Corn Milling, Processing and Generation of Co-products". An August 2007 report on "Utilization of Corn Milling Co-Products in Beef Cattle" from the Nebraska Corn Board & UNL-IANR, Erickson, et al. was also a key resource for this article.

Corn Use in Wet and Dry Milling Processes

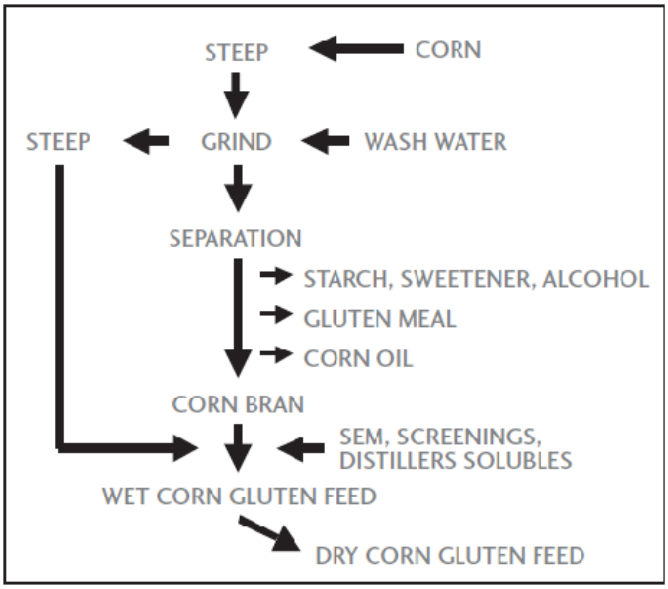
According to U.S. Census Bureau data, the amount of corn processed in U.S. wet-milling systems grew by an average of 1.2 million bushels per month, from 28-30 million bushels to as much as 90-96 million bushels per month during the January 2007 – November 2009 period (see figure #1). During this same 35 month period, the amount of corn processed in dry-milling systems in the U.S. grew by an average of 3.3 million bushels per month, from 105 to as much as 227 million bushels per month (in November 2009).



Corn Wet-Milling Processes

The corn wet-milling process is designed to efficiently separate various products and parts of shelled corn for various food and industrial uses. The primary products of the corn wet milling process include corn starch and edible corn oil. On average a bushel of corn weighs 56 pounds at 10% moisture, and produces 31.5 pounds of corn starch, 12.5 pounds of corn gluten feed, 2.5 lbs. of corn gluten meal, and 1.6 lbs. of corn oil. Figure 2 provides a schematic overview of the inputs and outputs corn wet milling process.

Figure 2. Overview of the Corn Wet Milling Process



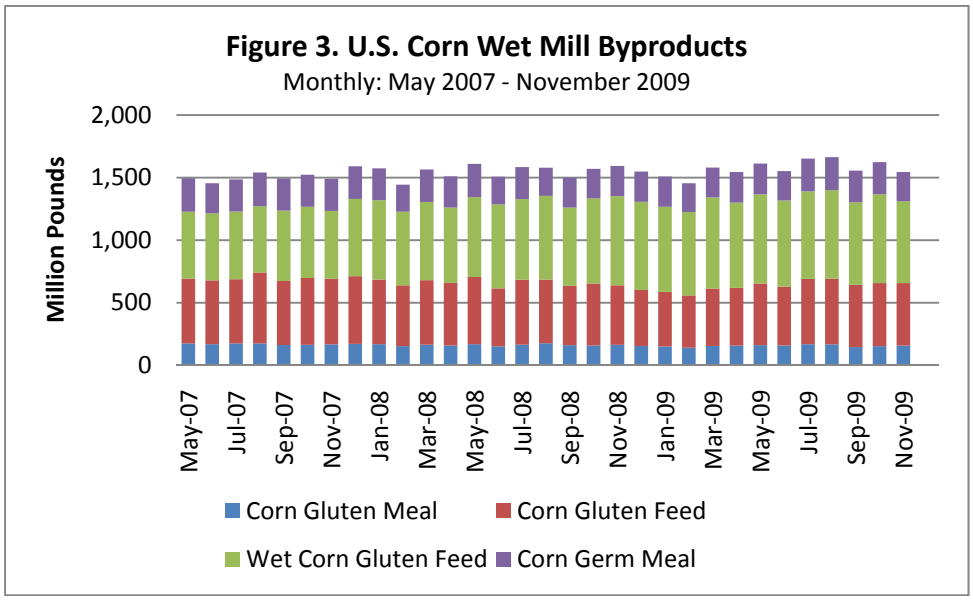
Source: "Utilization of Corn Milling Co-Products in Beef Cattle."
Nebraska Corn Board & UNL-IANR, Erickson, et al., August 2007

As described by Davis (2001), when shelled corn is physically delivered to a wet milling facility, it is first sampled to determine whether it meets the required physical quality standards. Assuming it meets these standards, the shelled corn is then transferred through a grain cleaning system to grain handling/storage facilities that are associated with the corn wet milling plant. From there, the corn feedstock is soaked in heated chemical solutions, resulting in a softening of the corn kernels and the absorption of soluble nutrients into the water solution.

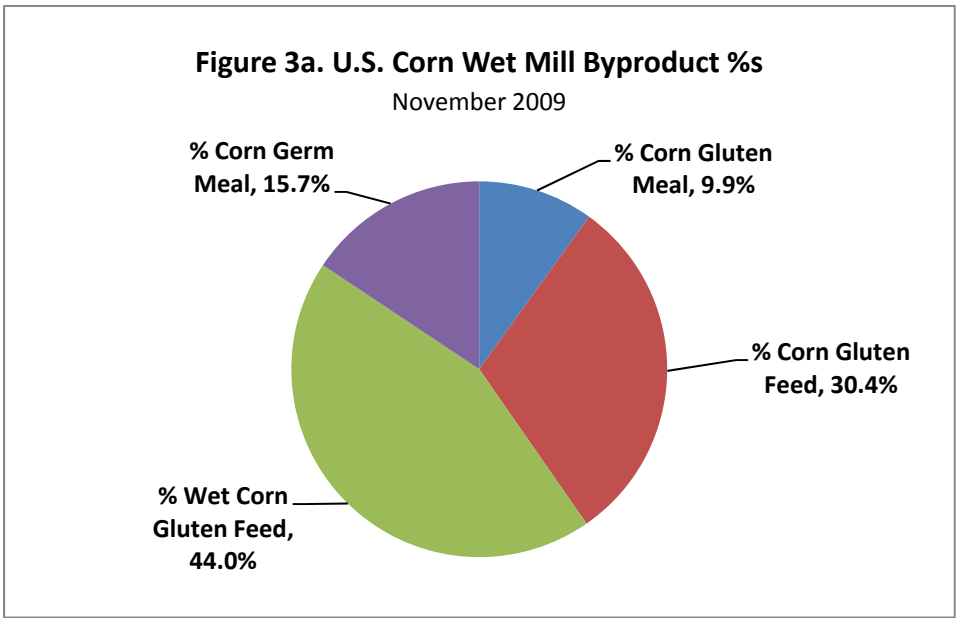
From this point forward in the process, various categories of corn wet million process byproducts are produced. Figure 3 illustrates the amount of these various corn wet mill process byproducts produced monthly during the May 2007 – November 2009 time period. Production of wet corn gluten feed has increased over this time period, while other wet milling process byproducts have declined.

Production of corn gluten meal from wet milling processes during this period averaged 162.2 million pounds per month, with an average decline of approximately 600,000 pounds per month. Corn gluten feed production averaged 498 million pounds per month, with an average monthly

decline of 1.7 million pounds over the period. Wet corn gluten feed production averaged 698.9 million pounds per month, with an average monthly increase of 5.9 million pounds. Production of corn germ meal averaged 247.6 million pounds per month, with an average monthly decline of 400,000 pounds.



During November 2009, 44% of the weight of wet milling process byproducts produced were in the form of wet corn gluten feed, followed by corn gluten feed at 30.4% (see figure 3a). Corn germ meal (15.7%) and corn gluten meal (9.9%) made up the rest of U.S. corn wet mill byproduct production.



Condensed Corn Fermented Extractives
The concentrate product formed after water is partially removed via evaporation is identified as "condensed corn fermented extractives". This is a high-energy liquid feed ingredient whose protein value content is 25% on a 50% solids basis. Condensed corn fermented extractives are sometimes combined with the corn gluten feed or sold separately as a liquid protein source for beef or dairy rations. It also can be used as a pellet binder and is a source of B-vitamins and minerals (Davis 2001).

Corn Germ Meal
Corn germ is then removed from the water soaked kernel in the wet milling process, and is then further processed to recover corn oil. What remains of the corn germ after removal of the corn oil product is identified as "corn germ meal" (in either wet or dry form), which is collected for use as a livestock feed. It typically contains 20% protein, 2% fat, and 9.5% fiber - with an amino acid balance that gives it value in poultry and swine rations and as a carrier of liquid feed nutrients.

After removal of the corn germ, the remainder of the corn kernel is screened to remove the bran – leaving corn starch and corn gluten protein to pass though a screening process (Davis 2001). Corn bran is combined with other wet mill process co-products to produce "corn gluten feed". This product is a medium protein ingredient composed of the bran and fibrous portions which may or may not contain condensed corn extractives and can be sold in wet or dry form. Wet and dry forms of corn gluten feed are widely used in complete feeds for dairy and beef cattle, poultry, swine and pet foods.

Dried Corn Gluten Feed
The dried form of corn gluten feed is made into pellets to facilitate handling and becomes "dried corn gluten feed". It typically contains 21% protein, 2.5% fat, and 8% fiber.

Wet Corn Gluten Feed
The wet form of corn gluten feed, i.e, "wet corn gluten feed" (45% dry matter) is perishable within 6 –10 days and must be fed or stored in an anaerobic environment.

Corn Gluten Meal
A slurry of starch and gluten (making up corn gluten feed) is further processed using centrifugal separators, causing the lighter corn gluten protein to separate from the heavier corn starch (Davis 2001). The corn gluten protein is concentrated and dried to form "corn gluten meal". This high protein concentrate product typically contains 60% protein, 2.5% fat and 1% fiber. See Davis (2001) for information on specific characteristics of this feed and livestock species for which it is particularly suited.

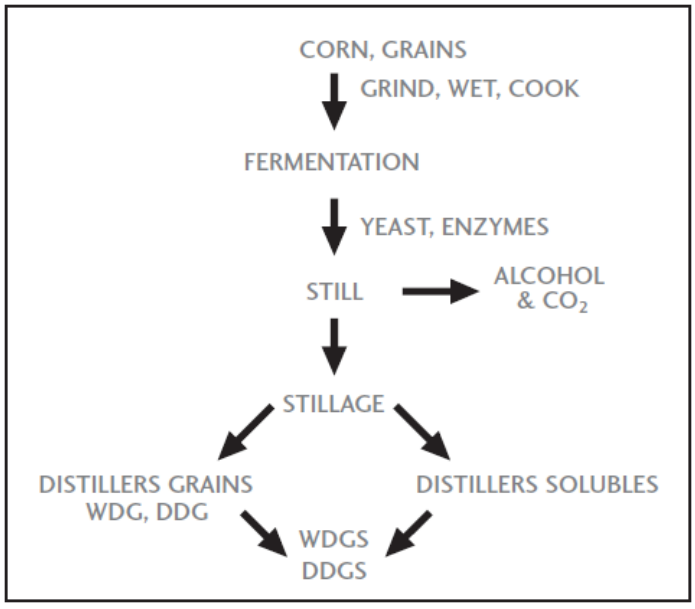
At this stage of the corn wet milling process, some of the starch is then washed and dried, or modified and dried and marketed to the food, paper and textile industries. The remaining starch can be processed into sweeteners or ethanol.

Corn Dry-Milling Processes

The large majority of ethanol plants built during the expansion-phase of the U.S. grain/starch ethanol industry leading up to the 2007-2009 period made use of corn dry-milling processes. Through the corn dry mill process, a bushel of corn weighing 56 pounds (test weight) typically produces 2.7 gallons of ethanol, 18 pounds of "distillers dried grains with solubles", and 18 pounds of CO_2.

Figure 4 provides an overview of the corn dry milling process, from the introduction of shelled corn as a feed stock through the production of ethanol, carbon dioxide (CO_2) and wet and dry distillers grains with solubles.

Figure 4. Overview of the Corn Dry Milling Process



Source: "Utilization of Corn Milling Co-Products in Beef Cattle." Nebraska Corn Board & UNL-IANR, Erickson, et al., August 2007

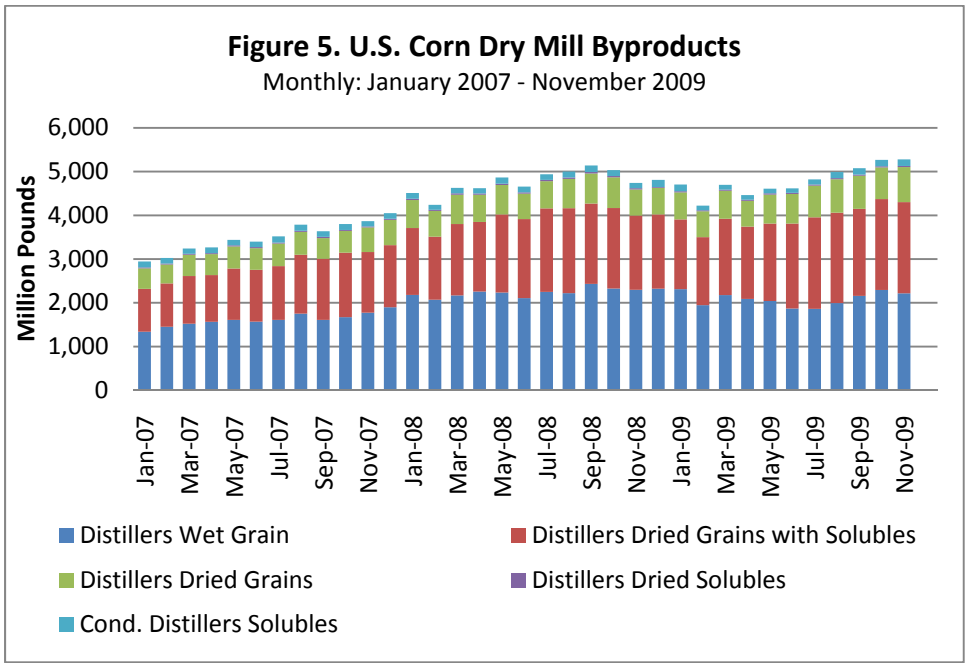
In the corn dry milling process, shelled corn arrives at the dry-mill processing facility and is first checked for quality (Davis 2001). Through a procedure of mashing, fermentation, cleaning and processing via a hammer mill, corn is milled into a medium-coarse to fine grind meal. This finely ground corn meal is mixed with fresh and recycled waters to form a "slurry". At the liquefaction stage of the process, hydrolysis is used to facilitate the conversion of corn starch to dextrin (long chain sugars).

After liquefaction of the starch is completed, the resulting mash is "cooked" and then cooled to 90°F and sent to a fermentation vessel to convert the dextrin into the simple sugar dextrose. Yeast species are then used to metabolically convert this dextrose into ethanol and carbon dioxide. This fermenting mash is referred to as a "beer". In this "stillage" form, corn protein and recycled waters provide nitrogen compounds that are absorbed by the yeast microbes in the

fermentation process. Ethanol is formed from corn-based starch at this stage of the dry milling process through a process of distillation (Davis 2001).

Then, "whole stillage" in the form of water and solids containing protein, fat and fiber are collected from the distillation base. Coarse solids are then separated from the liquid via centrifuge. The liquid is called "thin stillage". This thin stillage is then recycled to the beginning of the process or concentrated in an evaporator to become "corn condensed distillers solubles".

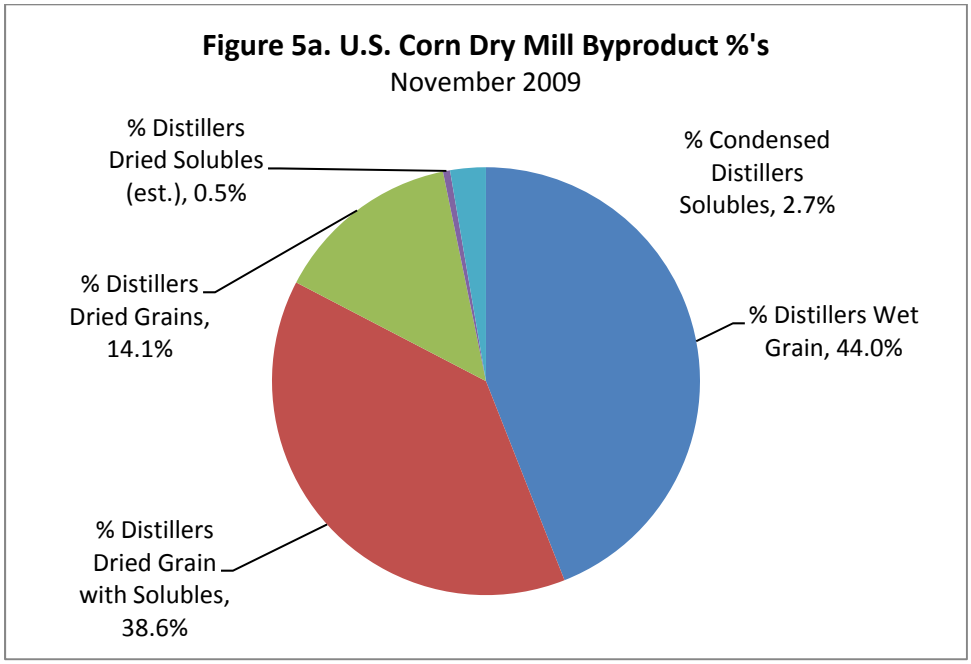
Figure 5 illustrates the amount of various corn dry mill process byproducts produced monthly during the January 2007 – November 2009 time period. Production of distillers wet grain, distillers dried grain, and distillers dried grains with solubles have each increased over this time period, while production of distillers dried solubles and condensed distillers solubles have remained approximately the same.



Production of distillers wet grain from dry mill processes during this period averaged 1,997.9 million pounds per month, with an average increase of approximately 21.1 million pounds per month. Distillers dried grains with solubles production averaged 1,600.4 million pounds per month, with an average monthly increase of 29.3 million pounds. Distillers dried grain production averaged 605.9 million pounds per month, with an average increase of 8.1 million pounds per month. Production of distillers dried solubles and condensed distillers soluble averaged 25.6 and 130 million pounds per month, respectively, with no change in monthly output over the time period.

During November 2009, 44% of the weight of dry mill process byproducts produced were in the form of distillers wet grain, followed by distillers dried grain with solubles at 38.6% (see figure

5a). Distillers dried grains (14.1%), condensed distillers soluble (2.7%) and distillers dried solubles (0.5%) made up the rest of U.S. corn dry mill byproduct production.



Corn Condensed Distillers Solubles
On a dry matter basis "corn condensed distillers solubles" typically contain 29% protein, 9% fat and 4% fiber. The dry matter content is typically between 25 – 50%, but can be dried to 5% moisture and marketed. Condensed distillers solubles are a highly palatable feedstuff, which can be used as a supplement to other poorer quality feed ingredients and/or roughages in livestock rations. Coarse solids collected from the centrifuge process are called "wetcake**"**.

Distillers Wet Grains (Wetcake)
Production and sales of the coarse solids collected from the centrifuge process (referred to as "wetcake") is common in the western Corn Belt states of Nebraska and Kansas.

Corn Distillers Dried Grains with Solubles
Wetcake and condensed solubles are then combined and dried in a rotary dryer to form the feed coproduct "corn distillers dried grains with solubles". This product contains all the nutrients from the incoming corn less the starch and has at least three times as many nutrients on a per unit basis as unprocessed shelled corn. Distillers dried grains with solubles typically contains 27% protein, 11% fat and 9% fiber, and can be used as a source of bypass protein in ruminants (beef and dairy cattle) and a feed ingredient for other livestock species (poultry, swine, aquaculture and pet foods). This product is also available in a wet form.

Distillers Dried Grains
The production of “distillers dried grains” (absent solubles) make up the remainder of U.S. corn dry mill byproducts.

Conclusions

The availability of U.S. Census Bureau data on livestock feed byproducts from wet and dry corn milling processes is potentially a great benefit to analysts of both the livestock feeding and the ethanol production industry. Further analysis is needed to determine how local and regional variation in the price of these feed products impacts the profitability of the U.S. ethanol industry.

Livestock feed related byproducts of the U.S. corn wet and dry mill industries in the United States have become economically viable inputs into feeding rations. Future expansion or contraction of the U.S. corn wet and dry milling industries will have an impact upon the continued availability of these feed products to U.S. livestock feeders.