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

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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.

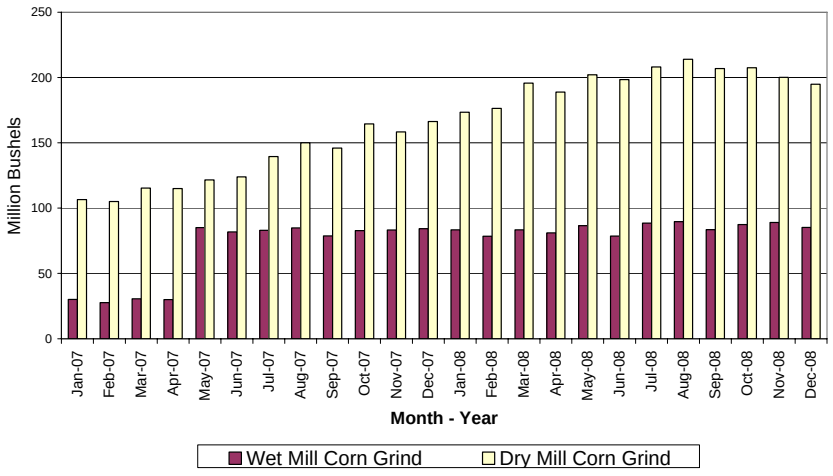
This article utilizes monthly information presented from U.S. Census Bureau Division of Manufacturing, Mining and Construction Statistics - Report M311J - Fats and Oils, Oilseed Crushing (Table 4b). It also references and builds upon information presented by Kelly S. Davis at the 2001 Minnesota Nutrition 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 from 30 million bushels to as much as 85-90 million bushels per month during the 2007-2008 period. (See figure #1) During this same 2-year period, the amount of corn processed in dry-milling systems in the U.S. grew from 105 to as much as 214 million bushels per month (in August 2008), although corn use declined toward the later part of 2008.

Figure 1. U.S. Wet & Dry Milling Corn Use

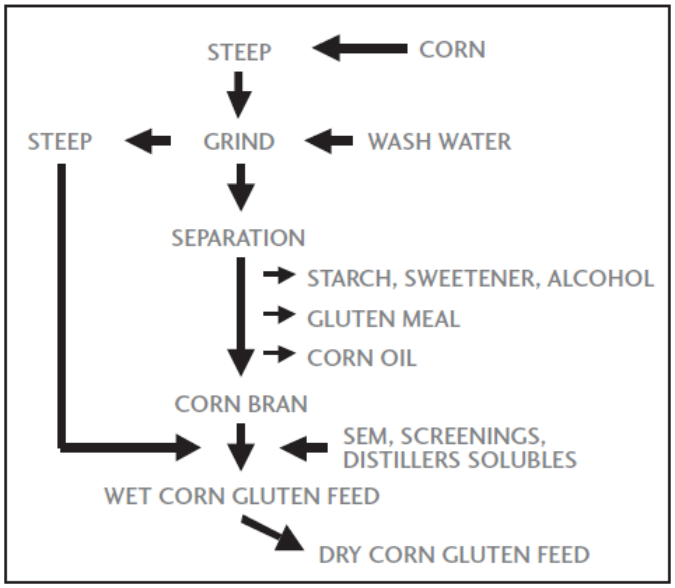
January 2007 - December 2008



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.

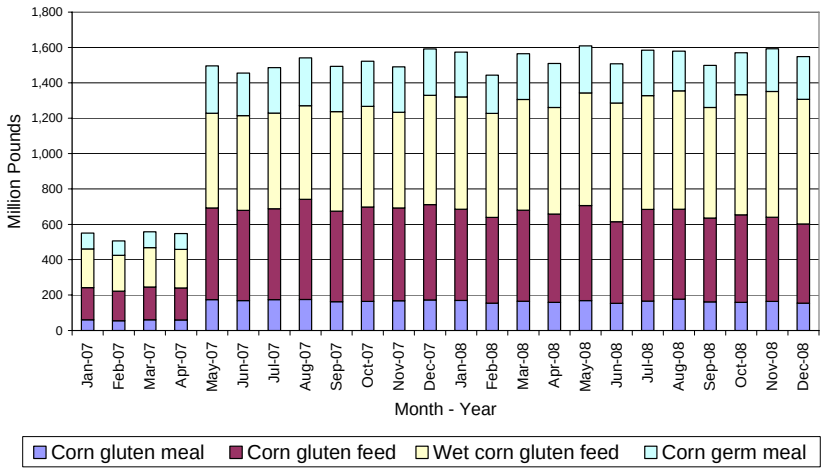
Condensed Corn Fermented Extractives

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. According to U.S. Census Bureau figures, an average of 248 million pounds per month of corn germ meal was produced from corn wet mill processes in the U.S. from April 2007 through December 2008. Corn germ meal accounted for 16% of the total quantity of corn wet mill process byproducts produced and marketed.

Figure 3 illustrates the amount of various corn wet mill process byproducts produced monthly during the 2007-2008 time period.

Figure 3. U.S. Corn Wet Mill Byproducts
January 2007 - December 2008



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. On average, 508 million pounds per month of dried corn gluten feed was produced from the corn wet mill processes in the U.S. during the April 2007 through December 2008 time period. Dried corn

gluten feed accounts for 33% of the total quantity of corn wet mill process byproducts produced and marketed.

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. An average of 611 million pounds per month of wet corn gluten feed was produced from corn wet mill processes in the U.S. during the April 2007 through December 2008 time period, accounting for 40% of the total quantity of corn wet mill process byproducts produced and marketed.

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. During the April 2007 through December 2008 time period an average of 166 million pounds per month of corn gluten meal was produced from U.S. corn wet mill processes, accounting for 11% of the total quantity of corn wet mill process byproducts produced and marketed.

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 2008-2009 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.

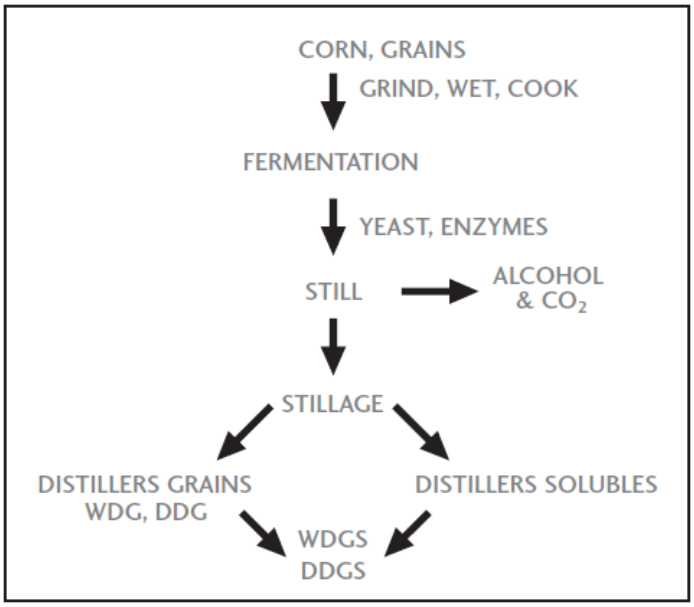
Figure 4 provides an overview of the corn dry milling process, from the introduction of shelled corn as a feed stock through the production of ethanol, carbon dioxide (CO_2) and wet and dry distillers grains with solubles.

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).

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

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**"**.

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. During 2008 an average of 133 million pounds per month of condensed distillers solubles was produced from corn dry mill processes in the U.S., accounting for 2.8% of the total quantity of corn dry mill process byproducts produced and marketed. Coarse solids collected from the centrifuge process are called "wetcake**"**.

Distillers Wet Grains (Wetcake)

Production of the coarse solids collected from the centrifuge process (referred to as "wetcake") averaged 2,236 million pounds per month in 2008, accounting for 47% of the total quantity of corn dry mill products produced and marketed. Wetcake sales from ethanol plants are 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. According to U.S. Census Bureau data, production of distillers dried grains with solubles averaged 1,726 million pounds per month in 2008, accounting for 36% of the total quantity of corn dry mill products produced and marketed.

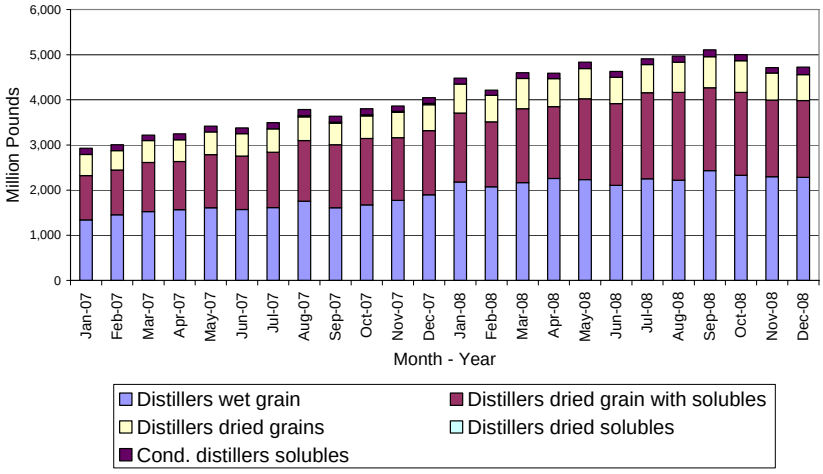
Distillers Dried Grains

The production of "distillers dried grains" (absent solubles) averaged 635 million pounds per month in 2008, accounting for 13% of the total quantity of corn dry mill products produced and marketed.

Figure 5 illustrates the amount of various corn dry mill process byproducts produced monthly during the 2007-2008 time period.

Figure 5. U.S. Corn Dry Mill Byproducts

January 2007 - December 2008



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 of the price impacts of these feed products upon local and regional feed markets, and upon the profitability of the U.S. ethanol industry is warranted.

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. Trends in U.S. corn wet and dry milling (and by implication ethanol production given its reliance on dry mill processes) will have a determinate impact upon the continued availability of these feed products to U.S. livestock feeders.