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BioEnergy

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Feed Ingredient Co-Products of Ethanol Fermentation from Corn

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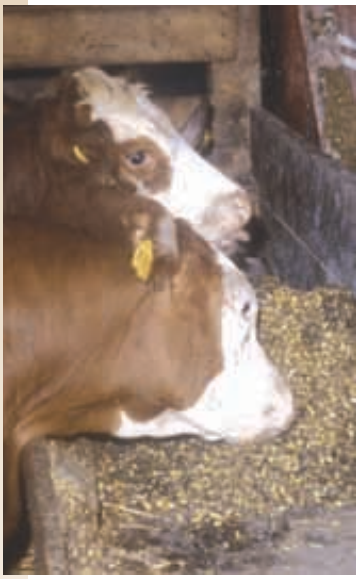

Introduction

Processing conditions prior to or after fermentation of corn to ethanol can greatly influence the quantity, quality, and nutritional composition of co-products. Most of the increase in ethanol production in the U.S. is expected to come from dry grind corn plants. Because of the large expected increase in distillers' dry grains with solubles (DDGS) production, processing modifications to the traditional dry grind plants (to recover non-fermentable fractions such as the germ, lipid, and fibrous portions) have and are being developed. As a result, DDGS with varied nutritional value are being produced.

The corn kernel is made up of four primary parts (Figure 1). The endosperm is the largest component at 82% of the kernel and is made up of primarily starch and protein. This starch fraction is what is fermented into ethanol. The germ is the next largest fraction at 12% of the kernel and is the primary site of corn oil. The pericarp is the seed hull and is 5% of the kernel. The tip cap is where the seed was attached to the cob and makes up 1% of the kernel.

Corn—Dry Grind Process

Dry grinding is typically used for most corn ethanol fermentation facilities and involves hammer milling the corn before the fermentation process. Ground corn is mixed with water, the pH is adjusted, the mixture is heated, and enzyme(s) is added to optimize the yeast fermentation process (Figure 2, page 2).

After the fermentation process, most of the fat and fibrous portions of the kernel remain, while a large portion (depending on fermentation efficiency and time) of the starch has been converted to ethanol. Water and all of the solids are collected from the distillation base (whole stillage) and centrifuged into the liquid portion (thin stillage, which can be concentrated or dried into corn condensed distillers solubles) and coarse solids. The coarse solids can then be fed wet or dried, with or without the condensed distillers' solubles, to make corn distillers' dried grains

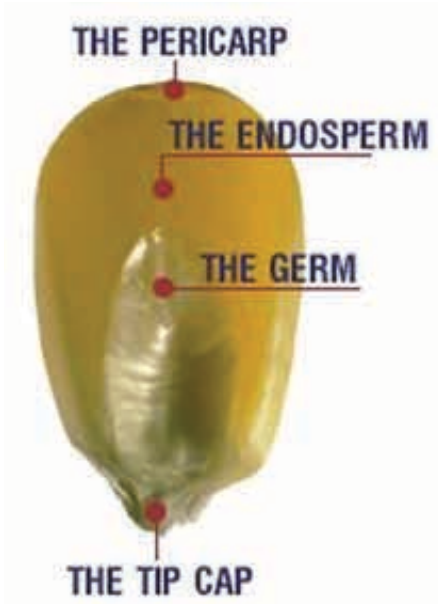

Figure 1. *Major Components of the Corn Kernel*

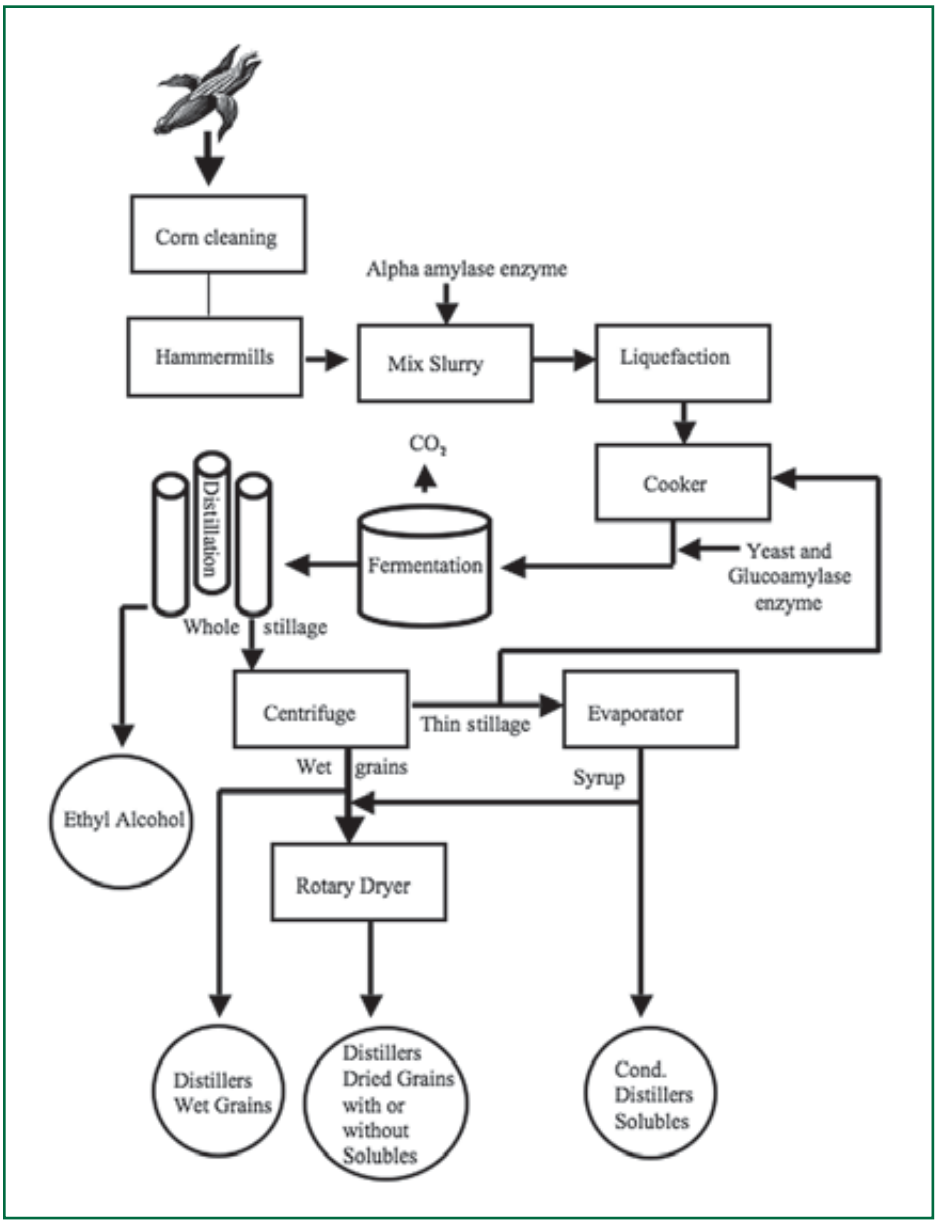

Figure 2. *Corn Dry Grinding Process Overview and Resulting Co-Products*

with or without solubles (DDG or DDGS, respectively). The DDGS comprises 27 to 30% of the original corn mass and is approximately 30% protein, 11% fat, and 7-9% fiber.

Corn—Wet Milling Process

Wet milling of corn was originally designed to produce pure corn starch. However, it is being used in some cases prior to fermentation to improve fermentation efficiency and produce other value added co-products (Figure 3).

For this process, corn is typically soaked in a dilute alkaline solution (steeped) to soften the corn kernel, and some nutrients are made soluble. The steep water is then evaporated to concentrate these nutrients, resulting in a high-energy, high-protein (50% on dry matter basis) feed ingredient—condensed corn fermented extractives or corn steep liquor. Often this is sold as a liquid feed (50% solids) or combined with other co-products and sold as gluten feed. The germ is then removed for oil extraction, after which the germ is sold (wet or dry) as a high protein

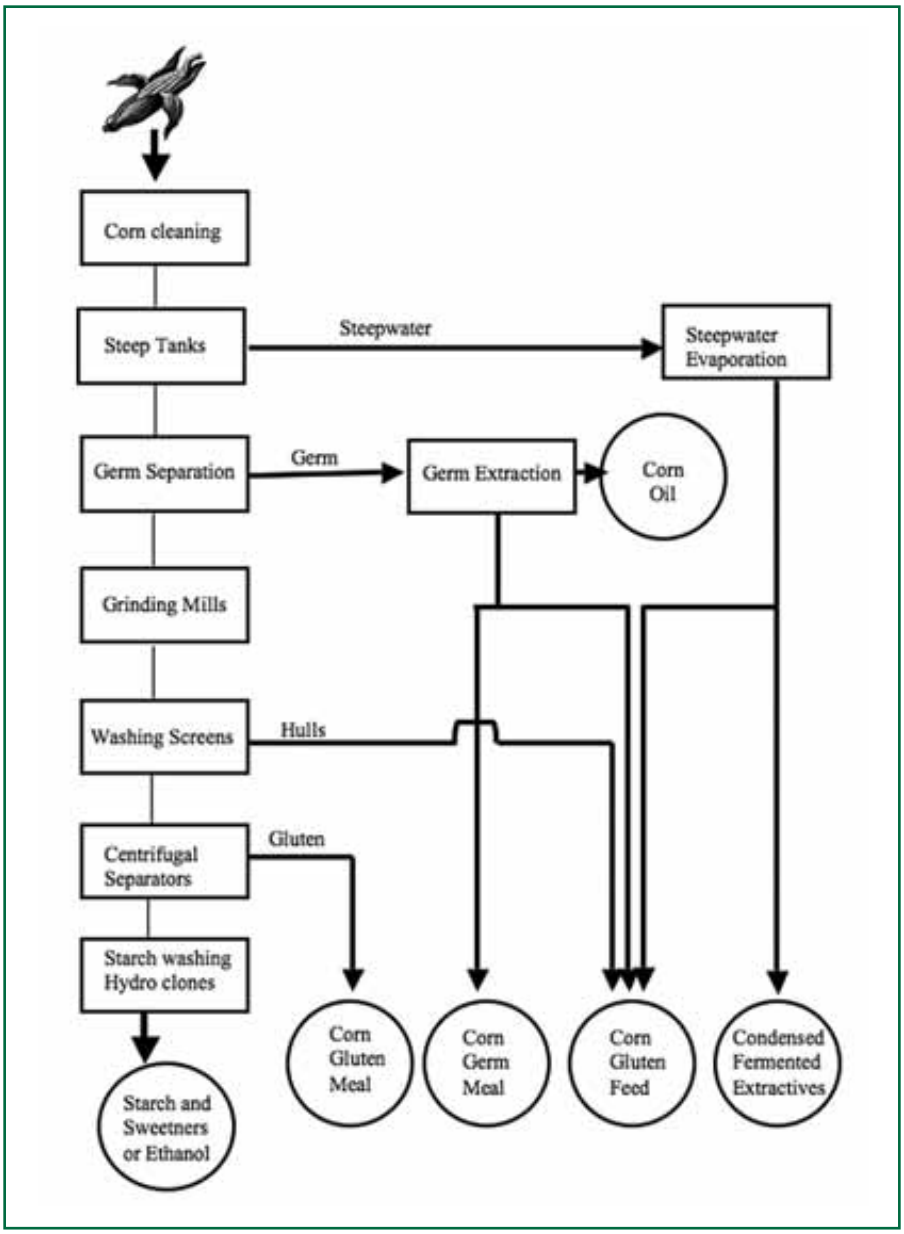

Figure 3. *Corn Wet Milling Process Overview and Resulting Co-Products*

feed ingredient—corn germ meal (20% protein, 2% fat, and 9.5% fiber). The remaining portion of the kernel, containing the starch and gluten protein, is screened to remove the fibrous bran portion. The two primary co-products of the wet milling process are as follows.

1) **Corn gluten feed** (22% of original corn mass): Residue (wet or dry form) remaining after removal of the larger portion of the starch, gluten, and germ. It is comprised mostly of corn bran and is typically 20 to 25% crude protein.

2) **Corn gluten meal** (4.5% of original corn mass): Dried residue remaining after removal of a larger part of the kernel's starch, germ, and bran, and is 60 to 65% crude protein. This is an excellent pigmenting feed for poultry and can serve as a rumen by-pass protein source for ruminants.

Additional Corn Processing Technologies

Several additional technologies have recently been developed to allow for more efficient ethanol fermentation and value added co-product production. Co-products

for livestock and poultry feed can differ in composition from traditional wet milling or dry grinding procedures. Several methods are currently being developed and show promise for providing additional value through improved fermentation properties and value-added co-products.

Quick germ quick fiber method involves soaking the ground corn in water with an enzyme(s) to increase specific gravity to float germ and fiber prior to fermentation. This results in a product with 28% protein, 5% fat, and 25% neutral detergent fiber.

Modified dry grinding process recovers the germ (drum degerminator) and pericarp fiber at the beginning of the dry grind process prior to fermentation. This results in a product with 24% protein, 8 to 9% fat, and 28% neutral detergent fiber.

Elusieve process includes fractionation of DDGS to remove fiber by sieving and air aspiration. This results in a product with 40+% protein, 15% fat, and 20% neutral detergent fiber.

While each of these processes provides additional co-products, new technologies are being developed. For example, future modification of fermentation yeasts could allow for increased lysine content of DDGS, a more desirable co-product.

Conclusion

Most of the ethanol production in Indiana will produce DDGS from the dry grind process. The nutritional content from and within a mill can vary due in part to fermentation characteristics, drying times, and changes in product recovery. As future production facilities become operational, modified wet milling or dry grinding prior to fermentation will largely influence the co-products available for use as livestock and poultry feed.

For Further Information

Lemenager et al. "The Value of Distillers' Grains as a Livestock Feed." ID-330. Purdue University Cooperative Extension Service (2006).

Mosier, N.S.; Ileleji, K. "How Fuel Ethanol Is Made from Corn." ID-328. Purdue University Cooperative Extension Service (2006).

Feeding Bio-Fuel Co-Products to Livestock – web-site (to be added).

National Corn Growers Association (http://www.ncga.com/)

Corn Refiners Association (http://www.corn.org/)

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