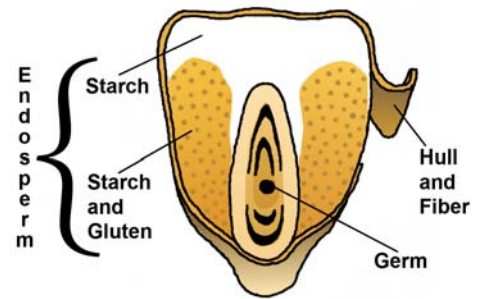


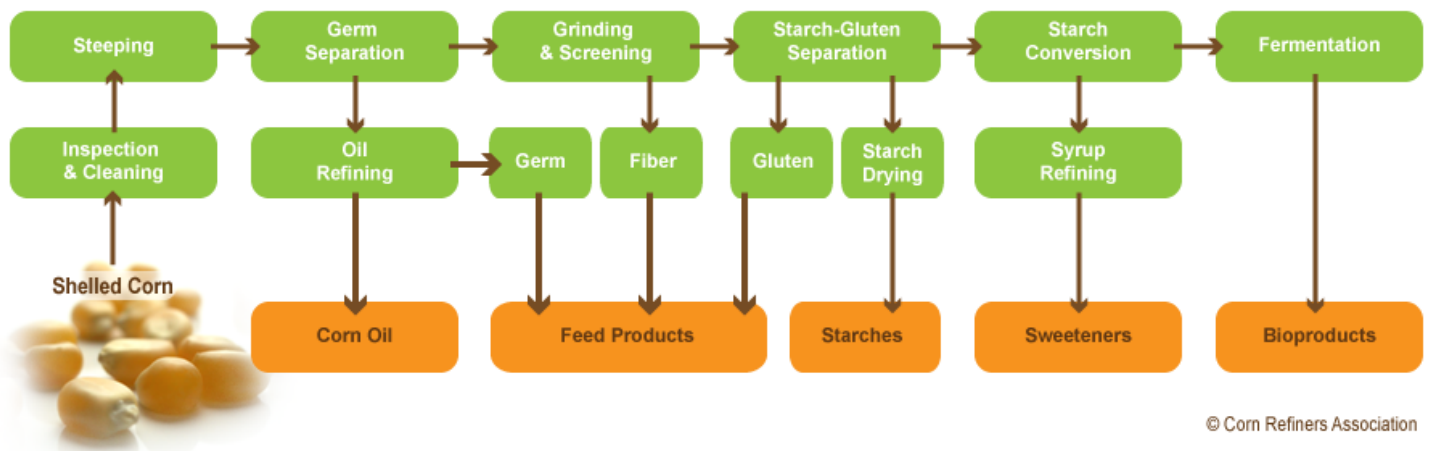
# The Corn Refining Process

For more than 150 years, corn refiners have been perfecting the process of separating corn into its component parts to create a myriad of value added products. The corn wet milling process separates corn into its four basic components: starch, germ, fiber, and protein.

There are five basic steps to accomplish this process. First the incoming corn is inspected and cleaned. Then it is steeped for 30 to 40 hours to begin breaking the starch and protein bonds. The next step in the process involves a coarse grind to separate the germ from the rest of the kernel. The remaining slurry consisting of fiber, starch, and protein is finely ground and screened to separate the fiber from the starch and protein. The starch is separated from the remaining slurry in hydrocyclones. The starch then can be converted to syrup or it can be made into several other products through a fermentation process.



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## Inspection & Cleaning

Corn refiners use #2 yellow dent corn, which is removed from the cob during harvesting. An average bushel of yellow dent corn weighs 56 pounds. Approximately 70 percent of the kernel is starch (from the endosperm), about 10 percent is protein (predominantly gluten), four percent is oil (extracted from the germ), and two percent is fiber (from the hull). It is the goal of the corn refining process to separate each component and then further refine it into specific products.

Corn arrives at the refining facility by truck, barge or railcar. Refinery staff inspect arriving corn shipments and clean them twice to remove pieces of cob, dust, chaff, and foreign materials. The corn is then conveyed to storage silos, holding up to 350,000 bushels, until ready to go to the refinery for steeping, the first processing step.

## Steeping

Each stainless steel steep tank holds about 3,000 bushels of corn for 30 to 40 hours of soaking in 50 degree Celsius water. During steeping, the kernels absorb water, increasing their moisture levels from 15 percent to 45 percent and more than doubling in size. The addition of 0.1 percent sulfur dioxide to the water prevents excessive bacterial growth in the warm environment. As the corn swells and softens, the mild acidity of the steepwater begins to loosen the gluten bonds within the corn and release the starch. After steeping, the corn is coarsely ground to break the

germ loose from other components. Steepwater is condensed to capture nutrients in the water for use in animal feeds and for a nutrient for later fermentation processes. The ground corn, in a water slurry, flows to the germ separators.

### **Germ Separation**

Cyclone separators spin the low density corn germ out of the slurry. The germs, containing about 85 percent of corn's oil, are pumped onto screens and washed repeatedly to remove any starch left in the mixture. A combination of mechanical and solvent processes extracts the oil from the germ. The oil is then refined and filtered into finished corn oil. The germ residue is saved as another useful component of animal feeds.

### **Fine Grinding & Screening**

The corn and water slurry leaves the germ separator for a second, more thorough, grinding in an impact or attrition-impact mill to release the starch and gluten from the fiber in the kernel. The suspension of starch, gluten, and fiber flows over fixed concave screens, which catch fiber but allow starch and gluten to pass through. The fiber is collected, slurried, and screened again to reclaim any residual starch or protein, then piped to the feed house as a major ingredient of animal feeds. The starch-gluten suspension, called mill starch, is piped to the starch separators.

### **Starch Separation**

Gluten has a low density compared to starch. By passing mill starch through a centrifuge, the gluten is readily spun out for use in animal feeds. The starch, with just one or two percent protein remaining, is diluted, washed eight to 14 times, rediluted, and washed again in hydroclones to remove the last trace of protein and produce high quality starch, typically more than 99.5 percent pure. Some of the starch is dried and marketed as unmodified corn starch, some is modified into specialty starches, but most is converted into corn syrups and glucose.

### **Syrup Conversion**

Starch, suspended in water, is liquefied in the presence of acid and/or enzymes which convert the starch to a low-glucose solution. Treatment with another enzyme continues the conversion process. Throughout the process, refiners can halt acid or enzyme actions at key points to produce the right mixture of sugars like glucose and maltose for syrups to meet different needs. In some syrups, the conversion of starch to sugars is halted at an early stage to produce low-to-medium sweetness syrups. In others, the conversion is allowed to proceed until the syrup is nearly all glucose. The syrup is refined in filters, centrifuges, and ion-exchange columns, and excess water is evaporated. Syrups are sold directly, crystallized into pure glucose, or processed further to create high fructose corn syrup.

### **Fermentation**

Glucose is one of the most fermentable of all of the sugars. Following conversion of starch to glucose, many corn refiners pipe glucose to fermentation facilities where the glucose is converted to alcohol by traditional yeast fermentation or to amino acids and other bioproducts through either yeast or bacterial fermentation. After fermentation, the resulting broth is distilled to recover alcohol or concentrated through membrane separation to produce other bioproducts. Carbon dioxide from fermentation is recaptured for sale and nutrients remaining after fermentation are used as components of animal feed ingredients.