Chapter 2

Food, Seed and Industrial Uses for Grains

Man has been harvesting grain for centuries. Beyond the geographic diversity inherent in the production and distribution of whole grains across the agricultural supply chain lies a wide and expanding variety of grain-based consumer products. While it only long been a basis for human food and livestock feed, there is a wide range of products that continues to expand to this day. These range from food products, vegetable oils, starch derived products, to biofuels, such as ethanol, gasohol, and bio-diesel, along with alcoholic beverages, including beer and whiskey. There are well over 1,000 grain-based products that can be found in the local supermarket, in addition to a broader range of grain-based products that can be found in the industrial sector.

The current list of uses for grain is long and wide and varied. This broad and evolving variety of grain-based products all contribute to market demand and the subsequent price of grains. Thus, it is essential for anyone working in the grain trade to develop a basic understanding of how the many uses for grain drive demand. Analysts typically divide demand for grain into the broad categories of:

- **Food, Seed and Industrial (FSI)** – Currently, FSI uses of grains in the U.S. account for about one-third of total domestic use.

- **Feed** – Feed use includes food consumed by animals. Coarse grains, (corn, barley, sorghum, oats, millet, triticale, and other cereal grains), are a major component of livestock feed. Demand is closely related to the number and types of animals (beef cattle, dairy cattle, swine, poultry, aquiculture, and companion animals) consuming feed within the livestock sector. The volume and type of grain and feed stuffs used that make up a feed ration greatly depends on their specific use, as well as their relative price relationships.

  Quantifying feed demand can be a challenge for market analysts. Feed use is a derived demand, as the lack of detailed data makes it is

difficult to quantify. As such, the numbers in the data are generally implied.

- **Residual** – Residual use refers to use for "left-over things". It refers items such as shrink, spoilage and waste, in addition to what remains unaccounted for within the supply chain pipeline.

  In many tables and charts showing supply and demand statistics, "Feed and Residual" are combined into a single number as both are implied in the data.

- **Exports / Imports** – Trade, or the combination of exports and imports makes up an important component of market analysis. Trade moves inventories of grain from areas of surplus into deficit areas where demand exceeds available local supply.

  Corn is the largest component of global coarse grain trade, and includes corn, sorghum, barley, oats, rye, millet, and mixed grains Corn generally accounting for about two-thirds of the volume over the past decade.

  The United States is the world's largest corn producer and exporter, currently exporting between 10 and 20 percent of its annual production, and making up approximately one-third of global corn exports. As such the size of the U.S. harvest has a major impact on global corn prices. Other major corn exporting countries include Brazil, Argentina, and the Ukraine.

Current Food, Seed and Industrial Uses

In this chapter we are going to take a closer look at the food, seed and industrial uses of grains.

FOOD

The use of grains in the production of food products varies greatly and comprises an important component of demand. Grains are the dominant or essential ingredient in products like flours, noodles, starch, grits, meals, extruded and other breakfasts, dextrose, fructose, corn oil, distilled beverages, and beer, just to name a few.

The proliferation of food products and food ingredients made from corn has combined with population growth to help drive the sharp increase in global corn consumption over the past century. This growth has occurred even in countries where rising incomes have resulted in lower per capita consumption of food grains such as wheat and rice.

As new food uses for corn and other grains multiply, global demand for

these grains is likely to grow.

SEED

Seed use is primarily determined by the intended planted area for the upcoming cropping year. While corn seed is often of very high value and can play a critical role in expanding and maintaining production, corn seed is a very small component of the corn trade volumes. Moreover, year on year demand for corn seed has historically been very stable.

INDUSTRIAL USES

The use of grains in processing and manufacturing for industrial uses makes up a large and important component of demand. By far the largest component of this sector is the fuel ethanol industry, but also includes demand from a wide arrange of products, including starch, and industrial alcohol, along with many other inedible uses.

THE MILLING PROCESS

An industrial milling process will strive to improve the resulting product's functionality, as well as maximizing the yield of product obtained from the original ingredients and inputs.

Milling will use of mechanical energy to break down particles through various mechanical processes, including a grinding media, pegs, rods, pebbles, and screens. As the grain passes through the mill, the mill's mechanical components act on the solid particles in the mixture to tear them apart or crush them, further reducing them in size.

An industrial milling process will strive to improve the resulting product's functionality, as well as maximizing the yield of product obtained from the original ingredients and inputs.

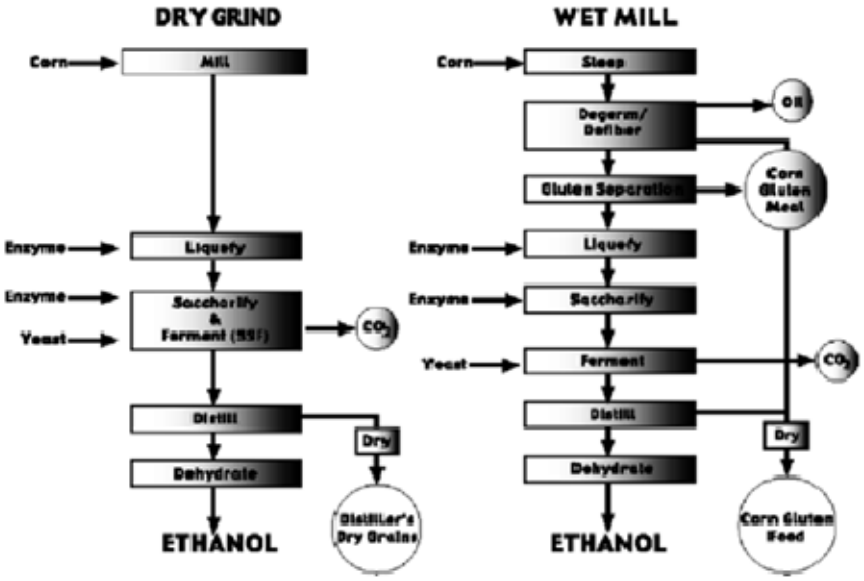
During processing, corn is either dry or wet milled depending on the desired end products:

- **Dry Millers:** Dry milling is essentially a simple grinding procedure that breaks up the whole grain. It is used to process grains into flakes for cereal, corn flour, corn grits, corn meal, and brewers' grits for beer production.

- **Wet Millers:** Wet milling involves dispersing the material in a liquid and using solid, grinding elements to reduce grain size. It is used to

process grains into high fructose corn syrup (HFCS), glucose and dextrose, starch, corn oil, beverage alcohol, industrial alcohol, and fuel ethanol.

Dry Milling vs Wet Milling Processes for Ethanol Production



Source: Bothast and Schlicher, 2005

Products can be broken down through either one of these processes. To understand the difference between the two processes, and the challenges that come with each, we first need to gain an understanding of the basics of milling.

DRY MILLING

Dry milling is essentially a simple grinding procedure that typically uses particle-on-particle contact to reduce materials' size. The grain is cleaned; then, through the use of steam, the moisture content is raised to around 20% to improve the milling process. The germ of the grains are usually removed for oil extraction, and the remaining grain is ground and sieved into many fractions varying in particle size and composition.

Dry milling utilizes no liquid element, and is most frequently used to produce dry materials like powders and granules, or to "de-agglomerate" and "de-lump" bulk materials. Dry milling is a less intensive process, which often makes it the first method considered for milling.

Currently, dry milling is primarily used to produce corn-based products for human and animal consumption, as well as for ethanol production.

This process is widely associated with the development of new bio-based associated by-products.

The primary products are flour, cornmeal and grits (ground corn with a particle size larger than typical cornmeal). Other products include corn bran, corn oil, and feed mixtures. These products are then utilized as ingredients or raw materials to manufacture other consumer and industrial based products.

Characteristics for corn ideally suited for dry milling are readily identifiable. The best corn for dry-milling has larger-sized kernels, low kernel size variability, harder kernel texture, and higher protein content. The harder type dent corns or flint corns have characteristics that are very well suited for dry milling. Harder corn is desired because when a kernel is dry milled it does not easily break (or crumble) like a soft textured corn. This results in larger yields of what is traditionally the highest value product: flaking grits.

Flaking grits are composed of nearly whole kernels of corn (minus the germ or oil fraction) that can subsequently be used to produce corn flakes. The larger the single piece of unbroken corn, the larger (and more desirable) the flake. Breakfast cereal manufacturers pay a premium for this dry-milled fraction.

PROCESS OVERVIEW

Dry Milling

Steps in Dry Milling: The main objective of the dry-milling process is to separate the endosperm, which is mainly composed of starch, from the germ and pericarp fibers. The milling process separates the grain into four distinct physical components: 1) the germ, 2) flour, 3) fine grits, 4) coarse grits. The separated materials are then further processes into food products utilized for human and animal consumption.

Tempering: Tempering is used to help separate the germ from the endosperm (i.e. the rest of the kernel). First, the grain is conveyed into a chamber and mixed with water or steam to hydrate the material for 10 to 30 minutes. This tempering process creates a differential in the moisture content between the germ and the endosperm. The difference in moisture absorption results in different rates of swelling, allowing more efficient separation of these two components due to the differential swelling of germ and endosperm. Another key benefit of tempering is that it makes the germ more flexible and resilient, without causing any movement of material out of kernel.

Degermination: The objective of degermination is to break down kernel to pericarp, endosperm, and germ.

Aspiration: Using air to separate the pericarp from the mixture of endosperm and germ. The process separates the components of a mixture based on differences in "particle terminal velocity," which is affected by size, shape and density.

Gravity Separation: Separates the germ from the endosperm based on differences in specific weight.

Milling and Sifting: using cylindrical rollers, hammer mill or ball mills for grinding materials. Sifting is then used to adjust the distribution of endosperm particles.

Oil Recovery: There are two methods for oil recovery used in dry milling: 1) Expelling, which is simple and inexpensive, but not commercially used in the U.S. for corn germ oil recovery due to its low oil yield and the presence of residuals oil in solid products; 2) Extraction which is most commonly used, although it is more expensive, due to its high oil yield and lower residual oil.

WET MILLING

Wet milling is a complex industrial process, also known as wet grinding. Today, most wet milling facilities have the capacity to process approximately 100,000 bushels (2,250 mts) or more of corn per day. The primary product is starch and starch derived chemicals.

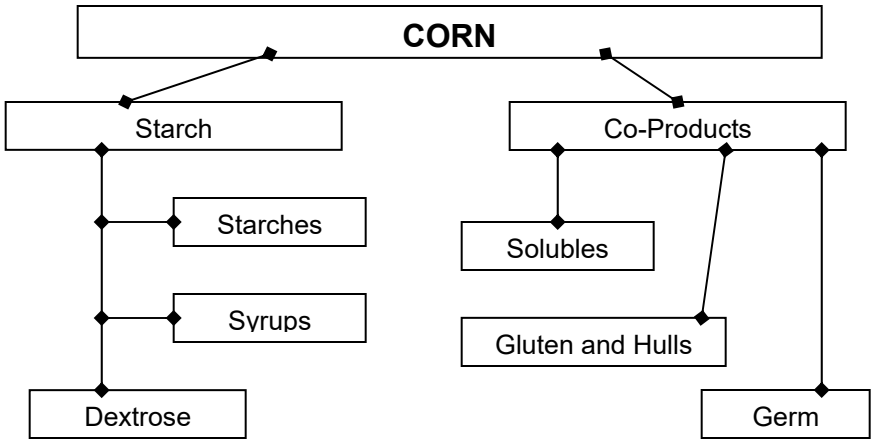
In wet milling, the grain is steeped in water, with or without sulfur dioxide, to soften the seed kernel to help separate the kernel's various component. Once the particles are suspended in a liquid slurry, they are dispersed in that liquid by shearing or crushing. Once the milling process is complete, these particles are ready for use or can be dried and separated for incorporation into additional products.

Wet milling is more complex than dry milling, due to the addition of a liquid; however, the process can also reduce a product into finer particles. This allows for the production of a greater variety of byproducts and can result in improved physical properties in your final product.

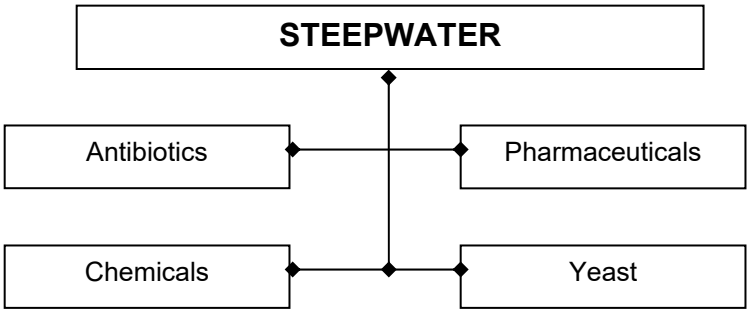
While dry milling is a less intensive process, which often makes it the first method considered, wet milling is the best and most efficient way to get to your preferred particle size if extremely small particles are your goal.

For example, wet-milling plants can separate a 56-pound bushel of corn into more than 31 pounds of cornstarch (which in turn can be converted into corn syrups or corn ethanol), 15 pounds of corn gluten meal for use in animal feed, and nearly 2 pounds of corn oil.

The Wet Milling Process



Upon arriving at a processing plant, each load of corn passes through a cleaner that removes foreign material and other impurities. Then the corn is soaked for 36 to 48 hours in hot water and sulfur dioxide. This process softens the protein (gluten) within the starch matrix while also toughening the germ.

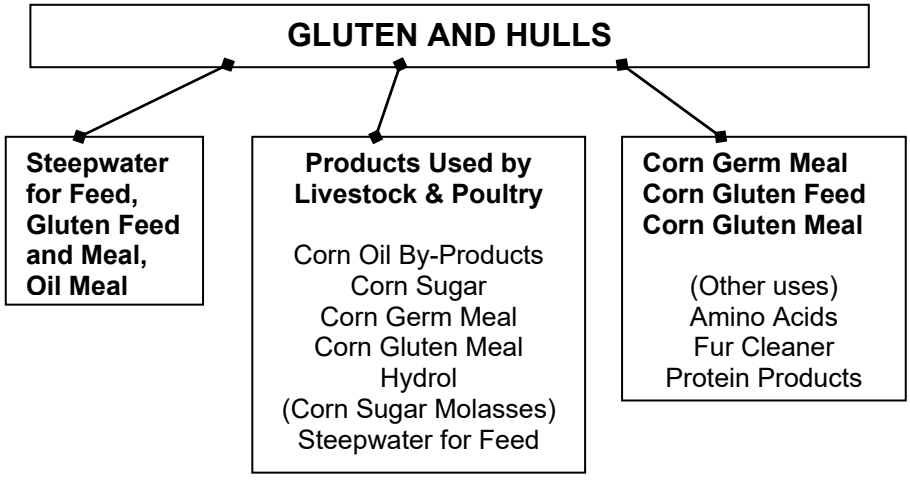


The softened corn kernel moves on to the degerminating mills and the resultant water-based mixture is called steep water. Steep water is highly nutritious and can be further processed for various uses. This additional processing consists of dismembering the weakened kernel and separating the bran. Then, the aqueous mixture of parts moves on to floatation tanks where a centrifugal hydrocyclone separates the heavier parts from the lighter germ.

The lighter germ is then crushed for its oil content. After the oil is removed, the remaining material is called, among other names, “corn oil cake,” and is ground into meal.

What remains after the germ is removed is first filtered and then returned to a high-speed centrifuge. In the centrifuge, gluten is separated from the mixture and removed. The gluten, as much as 70 percent protein, is mixed with the bran and/or the germ residue to become corn gluten meal or corn gluten feed.

The Wet Milling Process



Finally, with the gluten removed, the corn miller is left with the industrial heart of the corn kernel, the starch, or any feed grain that is refined through this process.

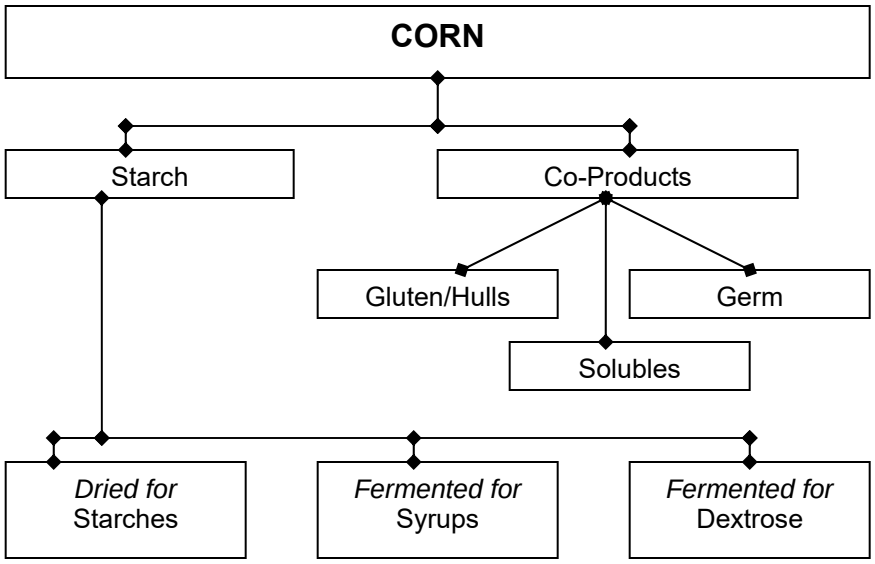
There are few readily identifiable corn traits that directly relate to increased starch yield. Many chemical and physical corn quality tests fail to adequately predict the performance of particular corn hybrids. The only clear corn kernel characteristics that result in higher yields of starch for wet millers are large kernels that are softer (i.e., more "floury") in texture.

THE WONDERS OF STARCH

Derived from the endosperm of grain, starch is the feedstock that yields nearly all current industrial feed grains products. From starch comes the vast array of industrial products created over the years by public and private sector research chemists.

Corn starch, or corn flour, is the starch derived from corn. The starch is obtained from the endosperm of the kernel. Although mostly used for cooking and as a household item, corn starch is used for many purposes in several industries, ranging from its use as a chemical additive for certain products, to medical therapy for certain illnesses.

The Wonders of Starch



In food, corn starch is a common food ingredient, often used to thicken sauces or soups, and to make corn syrup and other sugars.

However, corn starch is versatile and easily modified, which means it has many industrial uses as well; such as adhesives, in paper products, as an anti-sticking agent, and textile manufacturing, just to name a few. Corn starch can be used to manufacture bioplastics which may be used in a variety of plastic goods. In addition, it has medical uses as well, such as supplying glucose to people with glycogen storage disease.

However, like many other products found in fine granule, powder form, corn starch can present a hazard due to its flammability and potentially explosive nature.

ETHANOL

Ethanol is naturally produced through a biological fermentation of sugars by yeasts or via petrochemical processes such as ethylene hydration. Both dry-milling and wet-milling processing methods can be used in the production of ethanol, resulting in a variety of economically valuable coproducts.

A major use of grains, and more specifically corn, in the U.S. is in the production of ethanol (ethyl alcohol) as a first-generation liquid biofuel. It is most often used as a motor fuel, mainly as a biofuel additive with gasoline. Ethanol-blended fuel is widely used in Brazil, the United States, and is rapidly expanding elsewhere.

Most cars on the road in the U.S. today can run on blends of up to 10% ethanol. Ethanol represented 10% of the U.S. gasoline fuel supply derived from domestic sources. In the U.S. corn ethanol is typically blended with gasoline to produce "gasohol," an automotive fuel that is 10% ethanol. Some flexible-fuel vehicles are able to use up to 100% ethanol.

In addition to its use as a biofuel, there is also a large number of food and industrial uses for ethanol. Ethyl alcohol is the same type of alcohol found in alcoholic beverages, used as fuel. Grain can be fermented into a number of alcoholic beverages, notably bourbon and whiskey. Pure and denatured alcohol are used in the production of flavor extracts and concentrates for soft drinks and food products, distilled white vinegar, personal care products such as mouthwash, hair sprays, astringents, colognes and perfumes, and a wide range of chemical and pharmaceutical intermediates. It can also be used as a chemical solvent and in the synthesis of other organic compounds.

Ethanol

Uses of Grain Ethanol

- Alcoholic beverages
- Industrial alcohol
- Octane enhancer
- Oxygenate in motor fuels

COPRODUCTS OF THE MILLING PROCESS

Other Grain Co-Products from the Gluten and Hulls Used by Livestock, Poultry and Dairy:

- Corn germ meal
- Corn gluten feed
- Corn gluten meal
- Corn oil by-products
- Corn sugar (crude and refined)
- Hydrol (corn-sugar molasses)
- Steepwater for feed (condensed fermented
- corn extractives)
- Corn Germ Meal, Corn Gluten Feed, Corn
- Gluten Meal
- Other Uses
- Amino acids
- Fur cleaner
- Zein and other protein products

Three important animal feed products coming from the corn milling process include:

- Distillers Grains
- Corn Gluten Meal
- Corn Gluten Feed

Distillers Grains – are cereal based byproducts, or coproducts, of the distillation process. The resulting feed values and quality analysis is influenced by the type of feed stock, i.e. corn, barley, grain sorghum, rice or wheat, or other grains, as well as by the underlying milling process. The products are created by the milling process of distillation, and is subsequently sold for a variety of purposes, usually as feed stuffs for the livestock sector, especially ruminants.

There are two main sources of these grains. The traditional sources were from brewers. Brewer's spent grain usually refers to barley produced as a byproduct of brewing. More recently, the ethanol biofuel industry is now the primary source of these products as a byproduct of corn and/or grain sorghum. The mash left over from the process contains nutrients, such as protein, fiber, germ, vitamins, and minerals.

Corn-based distillers grains from the ethanol industry are rich in the protein, fat, minerals, yeast, and vitamins that animals need, making them a very popular feed ingredient for cattle, swine and poultry alike. They are marketed as DDGS, modified distillers grains with solubles (MDGS), wet distillers grains with solubles (WDGS), or condensed distillers solubles (CDS or corn syrup).

Coproducts of the Milling Process

In the U.S. cattle account for nearly 80% of DDGs consumption (50% attributed to beef cattle and 30% attributed to dairy cattle) and are a very important customer of this co-product. Cattle producers recognize the product as an economically beneficial, nutritionally valuable source of protein and energy. Research has found that increasing DDGS inclusion rates increases average daily gain and lowers the risk of subacute acidosis.

Increasingly, distillers grain products are being used in swine, poultry, and aquaculture feeds. New products require continuing research and feeding trials to determine nutritional value and performance response. There is much more to come within the next generation feed products. It is important to remember the value of current distillers grains products.

Wet Distillers Grains (**WDG**) – contains primarily unfermented grain residues (protein, fiber, fat and up to 70% moisture). Quality and analysis can vary significantly by supplier. WDG has a shelf life of four to five

days. Due to the water content, WDG transport is usually economically viable within 200 km of the ethanol production facility.

Dried Distillers Grains with Solubles (**DDGS**) – is WDG that has been dried with the concentrated thin stillage to 10–12% moisture. Drying is costly, as it requires further energy input. Each 56-pound bushel of corn used in dry-mill ethanol production generates approximately 17.4 pounds of DDGS.

It is important to note that due to differing inputs of feedstock, along with differing milling processes in each plant, product quality and analysis can vary significantly by supplier and point of origin. This will subsequently impact the underlying value proposition.

DDGS are currently the most prominent of the coproducts. Its primary use is as a feed ingredient for livestock. In the US, it is packaged and traded as a commodity that competes with other feed stuffs and a source of protein. It is part of the feed ration in both dairy and beef production. However, increasingly larger quantities of DDGS are making their way into swine and poultry feed rations.

Because it is a dry product, DDGS have an almost indefinite shelf life and may be shipped a distance to many markets regardless of its destination's proximity to an ethanol plant. As such, DDGS are well suited for exports to a wide range of destinations around the world.

Corn Gluten Meal – is a byproduct of corn processing that has historically been used as an animal feed. Despite the name, corn gluten does not contain true gluten, which is formed by the interaction of gliadin and gluten in proteins. The meal is a combination of bran fibers and the corn oil cake left from the extraction of corn oil, has protein content in excess of 60% and is a low-cost alternative to soybean meal or other expensive protein sources.

Coproducts of the Milling Process

Corn Germ – Corn germ is a dried co-product of the corn wet milling process, and is obtained after the coarse grinding of the corn kernel. During the wet milling process, the germ is isolated from the starch using cyclone separators, washed, and dried. It consists principally of the germs, containing the corn oil

Corn germ has a medium protein level feed stuff and is an excellent energy source. Furthermore it has good hydration and pelleting qualities.

Corn Germ Oil – Corn germ oil is a by-product of the corn oil milling process. The dried germ contains about 50% oil, in which the oil constitutes about 85% of the total amount of oil present in the corn. The

oil is produced by first expelling the germ and then extracting the expeller cake with n-hexane. Crude corn oil can be dark reddish in color. It is refined further by alkali neutralization followed by bleaching, dewaxing, and deodorization or by degumming, bleaching dewaxing and steam refining. The dewaxing step is only necessary when the corn oil is to be sold as salad oil.

Coproducts of the Milling Process

Corn Co-Products from the Germ:

Corn Oil, Refined - Food, Drug Uses

- Carriers for vitamins and other medicinal preparations
- Cooking oil
- Margarine
- Mayonnaise
- Potato chips
- Salad dressing
- Sauces, seasoning
- Shortening
- Soups

Corn Oil and Free Fatty Acids - Industrial Uses

- Chemicals and insecticides
- Lecithin (for pharmaceuticals, cosmetics, linoleum, printing inks, etc.)
- Paint and varnish
- Rubber substitutes
- Rust preventative (surface coatings)
- Soap
- Soluble oil (leather and tanning use)
- Textiles

FOOD PRODUCTS AND USES OF CORN

Corn is the third largest plant-based food source in the world. It is a major food in many parts of the world. Unlike many other cereal grains, corn flour is gluten-free and cannot be used alone to make rising breads.

In the United States and many other places, sweet corn is boiled or roasted on the cob, creamed, converted into hominy (hulled kernels) or meal, and cooked in corn puddings, mush, polenta, griddle cakes, cornbread, and scrapple. It is also used for popcorn, confections, and various manufactured breakfast cereal preparations. It is widely used in Latin American cuisine to make masa, a kind of dough used in such staple foods as arepas, tamales, and tortillas,

Most corn starch is used in the baking industry to improve the texture and delicacy of cakes. It does this by making the batter harder in nature and accordingly making this starch the most appropriate for use in the planning of cakes. It is also used to thicken sauces, puddings, and flavors. Corn starch powder is known for giving high qualities to ice cream, as well as salad dressings, pastries, and other such sweet food.

Food, Drug or Cosmetic Uses of Corn

(liquid or dried form)

- Baby foods
- Baking powder
- Bakery products (biscuits, bread, crackers, rolls, biscuits, doughnuts, pies, cakes, cookies, pretzels, etc.)
- Beverages, brewed (beer, ale, etc.)
- Beverages, carbonated
- Breakfast foods
- Caramel color
- Catsup, chili sauce, tomato sauce
- Cereals, prepared
- Cheese spreads and foods
- Chewing gum
- Chocolate products
- Citric acid
- Citrus juices
- Coffee whiteners
- Coloring, pure food mix
- Condensed milk, sweetened
- Confectionery
- Cordials and liqueurs
- Cream, frozen
- Dairy products
- Desserts
- Doughnuts (cake, yeast)
- Eggs, frozen or dried
- Extracts and flavors
- Fish, pickled
- Flavoring extracts
- Flours, prepared (including prepared mixes)
- Food acids
- Frostings and icings
- Fruit butters and juices
- Fruit drinks
- Fruits (canned, candied, fillings, frozen, etc.)

Food Products and Uses of Corn

Food Products and Uses of Corn

- Gelatin desserts
- Gravies and sauces
- Ice cream, water ices and sherbets
- Infant and Invalid feeding
- Jams, jellies, marmalades and preserves
- Lactic Acid
- Licorice
- Malted products
- Marshmallows and related products
- Meat products (bacon, bologna, ham, sausage, etc.)
- Medicinal preparations (drugs, pharmaceuticals)
- foods, pie fillings, toppings, etc.)
- Peanut butter
- Peas, canned
- Pectin, fruit
- Pickles and pickle products
- Prepared Mixes (cakes, frosting, icings, infant foods, pie fillings, pudding, etc.)
- Powders (ice cream, prepared dessert, pudding, summer drink, etc.)
- Mustard, prepared
- Pickles and pickle products
- Pie filling
- Precooked frozen meals
- Peanut butter
- Salad dressing
- Sauces (Catsup, seasoning, specialty, tomato, etc.)
- Seafood, frozen
- Soups, dehydrated
- Spices and mustard preparations
- Sugar, powdered
- Syrups (table, chocolate, cocoa, fruit, medicinal, soda fountain, cordials, etc.)
- Toppings
- Vegetables, canned
- Vinegar
- Wine
- Xanthan gums
- Yeast

Cosmetic, Drug or Personal Care Uses of Corn

(liquid or dried form)

- Antibiotics
- Aspirin

- Dietetic preparations
- Distillation products
- Drugs (fermentation process)Food and drug coating
- Medicinal preparations and intravenous (injections, pills, tablets, drugs, etc.)
- Mouthwash
- Toothpaste

Hydrol Corn-sugar molasses

- Leather tanning
- Livestock feed
- Organic acids
- Organic solvents
- Tobacco

Corn oil, a valued type of vegetable oil for its bland flavor and light color, is used primarily in the food sector. Corn oil can be converted into margarine by hydrogenation, a process in which the oil is combined with hydrogen at high temperature and pressure in the presence of a catalyst. It is favored as a salad oil and frying oil because it contains little cholesterol.

Corn Oil, Refined – Food and Drug Uses:

- Carriers for vitamins and other medicinal preparations in capsule form
- Cooking oil
- Margarine
- Mayonnaise
- Potato chips
- Salad dressing
- Sauces, seasoning
- Shortening
- Soups

Food Products and Uses of Corn

INDUSTRIAL PRODUCTS AND USES OF CORN

The industrial uses for grain make up an import sector of demand. While in the United States, ethanol production makes up the largest component of this sector, there is a wide variety of other industrial uses. Corn starch can be used to manufacture bioplastics, as well in the production of paper and textiles. It may be used as an adhesive in book and paper conservation. Adhesive made from corn starch dry with a slight sheen comparable to wheat starch.

The following in an incomplete list of industrial uses:

Industrial Uses

- Acids, commercial (lactic, acetic, gluconic, etc.)
- Adhesives
- Amino acids
- Chemicals (calcium, lactate, sodium lactate, etc.)
- Citric
- Dyes
- Electroplating and galvanizing
- Enzymes
- Lactic acid polymers
- Leather tanning
- Lysine
- Mannitol
- Paper manufacturing
- Rubber (cold process)
- Sizing materials
- Sorbitol
- Textiles, dyeing and finishing
- Threonine
- Tryptophan

Industrial Uses - Corn Starch

Industrial Products and Uses of Corn

- Abrasive paper and cloth
- Adhesives (glues, mucilages, gums, etc.)
- Batteries, dry cell
- Binder or binding agents
- Board (corrugating, laminating, solid fiberboard, cardboard)
- Boiler compounds
- Bookbinding
- Briquettes Ceramics (as clay binder)
- Chemicals Cleaners, detergents
- Coatings on wood, metal and paper
- Color carrier (in paper and textile printing)
- Cord polishing, sizing
- Cork products
- Crayon and chalk (as a binder)
- Dispersing and standard- izing agent
- Dressing, surgical
- Dyes (as a bodying agent, carrier diluent, etc.)
- Fermentation processes
- Fiberglass size

- Fireworks
- Insecticide powders
- Insulating material (glass wool, rock wool, etc.)
- Lubricating agents
- Oilcloth
- Oil-well drilling (drilling mud)
- Ore refining (electrolytic reduction process, flotation process, etc.)
- Paints (cleaning compounds, cold-water and latex paints, poster lacquers, etc.)
- Paper and paper products manufacture
- Plastics (molded)
- Plywood (interior)
- Printing
- Protective colloids (emulsions)
- Soaps and cleaners
- Textiles (warp sizing and finishing)
- Tile, ceiling
- Tires, rubber
- Wallboard and wallpaper
- Water recovery, industrial

Industrial Uses – Corn Syrup

- Adhesives (plasticizing agent)
- Chemicals
- Dyes and inks
- Explosives
- Leather tanning (chrome process)
- Metal plating
- Paper, glassine and parchment
- Plasticizer
- Polish, shoe
- Rayon (viscose process)
- Textiles, for finishing
- Theatrical makeup
- Tobacco and tobacco products

Industrial Products and Uses of Corn

Hydrol Corn-sugar molasses

- Leather tanning
- Livestock feed
- Organic acids
- Organic solvents
- Tobacco

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